HELPING AMERICA COMPETE

The Role of Federal Scientific & Technical Information

UNITED STATES CONGRESS
OFFICE OF TECHNOLOGY ASSESSMENT

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The Role of Federal Scientific & Technical Information

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Foreword

This Special Report assesses how Federal scientific and technical information (STI) can contribute to a more competitive America and what actions are needed to realize this potential. The report was prepared in response to a request from the House Committee on Science, Space, and Technology.

Global change is a fact of contemporary life—whether in the political, economic, or technological spheres. U.S. leadership in all of these areas is being challenged. We need to take actions that can help renew the U.S. competitive edge in the worldwide marketplace of ideas, products, and services, and to provide leadership on global issues such as the environment.

A key area of U.S. strength could and should be our scientific and technical information. The U.S. Government is the largest single source of STI in the world—ranging from technical reports on aerospace propulsion and solar thermal electric systems to satellite data on oceanic and atmospheric trends to bibliographic indices on medical and agricultural research.

Yet the United States is not taking full advantage of opportunities to use Federal STI as part of a strategy to renew the U.S. competitive edge. STI is very important to scientists and engineers in a wide range of research, development, and commercial activities. They spend a lot of time on STI—time that is valued, conservatively, at several billions of dollars per year just for federally funded researchers. When used efficiently, Federal STI pays off handsomely.

The Special Report has benefited from discussion at an August 1989 OTA workshop, several rounds of comments on earlier drafts, and debate on related topics at recent executive branch meetings and congressional hearings. OTA appreciates the participation of the Office of Science and Technology Policy, Office of Management and Budget, and Federal agency officials and members of the scientific, academic, library, business, and consumer communities, among others, who provided useful comments and information. The report is, however, solely the responsibility of OTA and not of those who assisted us.

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Summary

The United States must make better use of its scientific and technical information (STI) resources, if it wishes to be competitive in world markets and maintain its leadership. STI is an essential ingredient of the innovation process—from education and research to product development and manufacturing. It is a major product of the $65 billion per year the U.S. Government spends on research and development (R&D); researchers need ready access to STI if they are to stay at the cutting edge.[1] Many issues of our time—health, energy, transportation, and climate change—require STI to understand the nature and complexities of the problem and to identify and assess possible solutions. **STI is important not only to scientists and engineers but to political, business, and other leaders who must make decisions related to science and technology, and to the citizens who must live with the consequences of these decisions.**

The electronic collection, storage, and dissemination of STI is a vision of the future that is rapidly becoming reality. Electronic STI offers the prospect of fast, efficient, and inexpensive access to databases and documents. Scientists now use online computer networks to transmit STI around the nation and throughout the world. Others are experimenting with compact optical disks that can store a quarter million pages of text on one disk.[2]

The Federal Government has a golden opportunity to help the United States sustain a competitive position in scientific and technical information. The United States has, at the moment, the necessary information and technology base on which to build a strong national effort. Congress intended that the President's Office of Science and Technology Policy (OSTP), established in 1976,[3] provide executive branch leadership on STI; OSTP has thus far failed in this mission.[4]

During the 1980s, STI was subsumed in the larger debates over national information policy and science and technology policy. The Office of Management and Budget (OMB) dominated executive branch information policymaking and showed little interest in STI. OSTP failed to recognize STI as an integral part of overall S&T policy, and did not assert itself in many of the policy issues that affected STI. Federal STI programs suffered as a result.

Executive branch leadership is imperative because STI is generated by many Federal R&D agencies that must be coordinated if the government's STI efforts are to be successful. Agencies have set up a variety of ad hoc coordinating mechanisms for specific aspects of STI; but an overall, integrated approach is lacking. One of these existing committees could be expanded and chartered to serve a broader purpose. Alternatively, a new high-level interagency committee on STI could be established, with representatives from the R&D programs that generate STI, the agency data centers and technical document distribution offices, and governmentwide dissemination agencies such as the Government Printing Office (GPO) and National Technical Information Service (NTIS).

Whether through an interagency committee, OSTP and OMB guidance, or other means, the

[1]*See*, for example, U.S. Congress, House, Committee on Science and Technology, *The Impact of Information Technology on Science*, Science Policy Study, Background Paper No. 5 prepared by the Congressional Research Service, 99th Cong., 2nd sess. (Washington, DC: U.S. Government Printing Office, September 1986); and National Academy of Sciences, Committee on Science, Engineering, and Public Policy, *Information Technology and the Conduct of Research* (Washington, DC: National Academy Press, 1989).

[2]See the appendix for a discussion of technological opportunities.

[3]Public Law 94-282, the "National Science and Technology Policy, Organization, and Priorities Act of 1976," May 11, 1976.

[4]OSTP is in the process of deciding how to address STI issues in the Bush Administration; see remarks of OSTP Director, D. Allan Bromley, before a March 21, 1990, forum of the Federal Library and Information Center Committee, Washington, DC.

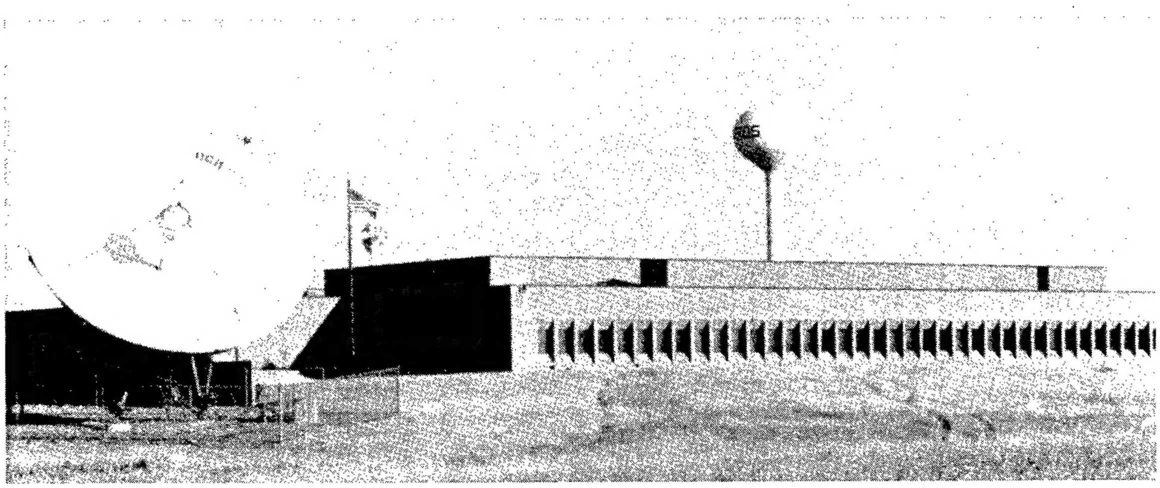

Photo credit: EROS Data Center, USGS

The Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, SD, receives and stores data from Landsat and other Earth-observing satellites. The total earth sciences data volume managed by Federal agencies (primarily NASA, USGS, and NOAA) is projected to increase over two orders of magnitude by the year 2000 to about 10,000 terabytes. NASA's Earth Observing System alone will generate an additional terabyte of data every day; this is equivalent to 10,000 Washington, DC telephone books (white pages) or 520,000 text books (at 200 pages each) per day.

success of the Federal STI program will depend on progress in four key areas:

1. technical standards for databases and documents (graphics as well as text), so that STI can be electronically moved among agencies and users with ease and efficiency;[5]
2. indexing of databases and documents, so that STI users in and out of the government know what and where STI exists;[6]
3. funding for basic STI activities in agency R&D budgets, to ensure the quality of STI, its proper storage, and dissemination to users;[7]
4. end-user involvement in all agency STI programs, so that Federal STI is disseminated in user-friendly formats that meet user needs and are compatible with the equipment and technical capabilities of the users.

Electronic media offer the only way to manage the massive volume and complexity of Federal STI; yet Federal agencies must avoid "technophoria," i.e., unrealistically optimistic expectations of the technology.[8] The transition to electronic formats, while inevitable, will be difficult for many users.[9]

[5]The standards-setting effort would heavily involve the National Institute of Standards and Technology, the designated lead standards agency for the Federal Government, and rely to the maximum extent possible on standards developed by private sector and international standards-setting organizations.

[6]Indexing would be coordinated with related activities by the National Technical Information Service and Government Printing Office; however, preparation of keywords and abstracts could, in any event, be the responsibility of the R&D agencies and their contractors and grantees.

[7]For a discussion of the severe problems that result from underfunding of agency STI activities, see U.S. General Accounting Office, *Space Operations: NASA Is Not Properly Safeguarding Valuable Data From Past Missions*, Report to the Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, GAO/IMTEC-90-1, March 1990. GAO is conducting similar audits of NOAA and USGS data archives.

[8]Term coined by C.R. McClure of Syracuse University in testimony before an Oct. 12, 1989, hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology.

[9]While OTA projects a dominant role for electronic formats, paper (and to a lesser extent microfiche) formats will be heavily used for the foreseeable future. But most paper documents will be produced by electronic printing from computerized databases; the same electronic database can be used to disseminate STI online over networks, on magnetic tape or diskette, or on compact optical disk, as well as on paper or microfiche. In this way, it will be possible to accommodate both high-tech and low-tech needs of STI users.

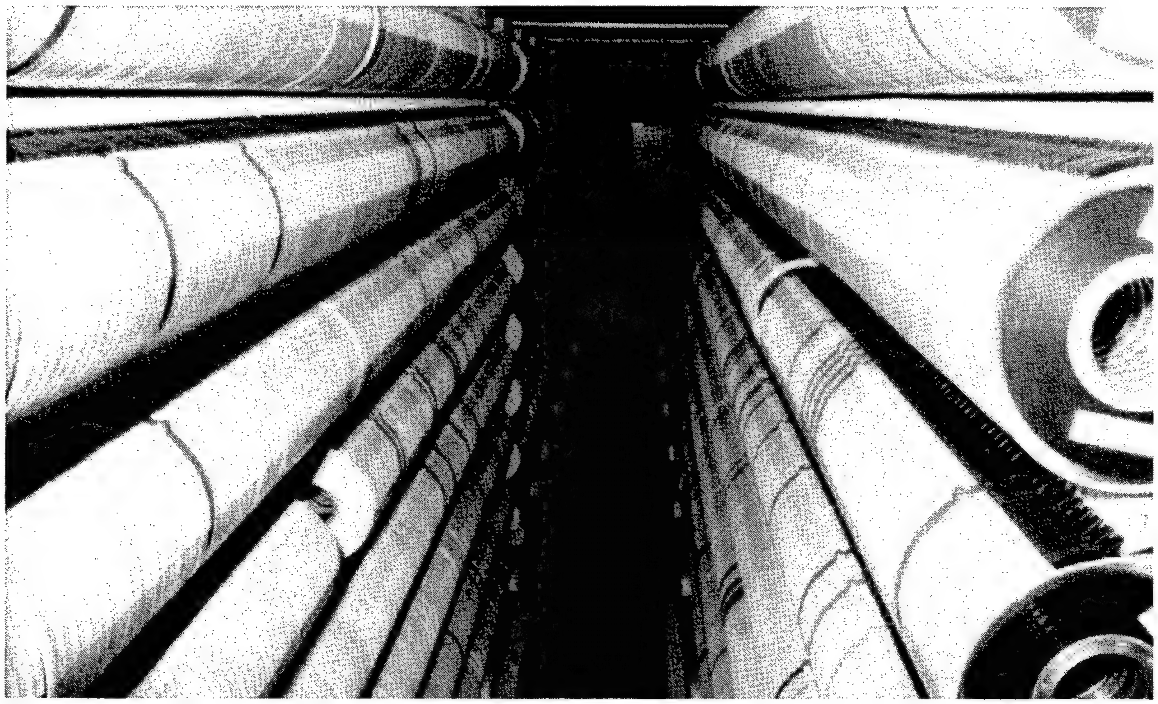

Photo credit: National Space Science Data Center, NASA

The National Space Science Data Center in Greenbelt, MD, is the largest space data-archive in the world, with about 120,000 magnetic computer tapes of digital data currently on file. The computer tape is still the dominant medium for storing space data, but the tapes are difficult and expensive for many researchers to use. New technologies make it possible to carry out a gradual transition from magnetic tapes to higher density storage media such as optical disks or tapes and digital tape cartridges.

Progress on STI also depends on resolving governmentwide information dissemination policy issues. During the 1980s, OMB used its authority under the Paperwork Reduction Act to favor private-sector responsibility for Federal information dissemination. The OMB view was controversial and sent mixed signals to the Federal R&D agencies about whether electronic STI should be aggressively pursued. Legislation pending before Congress would rebalance government policy to emphasize that Federal agencies (including the R&D agencies) have the primary responsibility for dissemination of information generated for agency missions, with an important supplementary or complementary—rather than preemptive—role for the private sector.[10] This legislation also addresses information management, pricing, public access, due process, and other policy matters that would directly affect STI.[11]

The U.S. scientific and technical enterprise depends on the open exchange of STI. Until the 1980s, the premise of openness was generally violated only in narrowly defined areas of

[10]See S. 1742, the "Federal Information Resources Management Act of 1989," 101st Cong., 1st sess., Oct. 6, 1989; and H.R. 3695, the "Paperwork Reducation and Federal Information Resources Management Act of 1989," 101st Cong., 1st sess., Nov. 17, 1989, ordered to be reported by the House Committee on Government Operations, Mar. 13, 1990. Also see Office of Management and Budget, "Second Advance Notice of Further Policy Development on Dissemination of Information," *Federal Register*, vol. 54, No. 114, June 15, 1989, pp. 25554-25559; U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, *Federal Information Dissemination Policies and Practices*, Hearings, 101st Cong., 1st sess., Apr. 18, May 28, and July 11, 1989 (Washington, DC: U.S. Government Printing Office, 1989); and U.S. Congress, Senate, Committee on Governmental Affairs, Subcommittee on Government Information and Regulation, *Reauthorization of the Paperwork Reduction Act*, Hearings, 101st Cong., 1st sess., June 12 and 16, 1989 (Washington, DC: U.S. Government Printing Office, 1989).

[11]See OTA comments on S. 1742, prepared for a Feb. 21-22, 1990, hearing of the Senate Committee on Governmental Affairs.

Photo credit: National Space Science Data Center, NASA

NASA and other Federal science agencies are currently experimenting with optical disks—primarily the 12-inch WORM (Write Once-Read Manytimes) and 4.75-inch CD-ROM (Compact Disk-Read Only Memory). A typical CD-ROM can store up to about 600 megabytes. This is equivalent to roughly 300,000 text pages (at 250 words per page), 1,650 floppy diskettes, 30 of the 20-megabyte hard disks, or 15 of the 1,600 bits-per-inch 9-track magnetic computer tapes. For many applications, CD-ROM is much less expensive than computer tapes, and requires only a microcomputer and CD-ROM reader rather than a more expensive mini- or main-frame computer needed for tapes.

national security. In recent years, the bases for restrictions on open dissemination of information have been extended to: a) so-called "unclassified but sensitive" STI that might compromise national security; b) the transfer of control over federally funded technical data and technology from the government to the private sector to promote commercialization; and c) limitations on access by foreign governments and companies to Federal STI to maintain the economic competitiveness of the United States.

Globalization of the economy means that a growing fraction of U.S. domestic R&D companies operate under foreign ownership or with foreign partners, just as many U.S. corporations have their own foreign subsidiaries or partners. Similar trends are evident in the commercial information sector, to the point where one cannot assume that a U.S. information vendor operates under domestic rather than foreign ownership, and vice versa. Under these conditions, the old approaches to controlling the flow of STI do not work and need to be revisited. Many of them may not be needed at all.

Another vexing issue is the role of the governmentwide dissemination and archival agencies in the decentralized, increasingly electronic environment of Federal STI. The creation, storage, and dissemination of electronic STI is decentralized within the R&D agencies for several reasons:

- The volume of STI is vast. Centralizing all STI in one databank is not technically or administratively feasible.
- The technical systems for creating, storing, and disseminating STI are typically closely tied to agency automation systems. Centralizing STI could foreclose innovation and opportunities for improving productivity in the agencies.
- The diversity of STI uses spans a number of disciplines and research areas. Centralizing STI would complicate communications between the STI process and the users.

A key challenge is how to preserve and strengthen the indexing, archiving, and distribution roles of the: 1) GPO;[12] 2) Depository Library Program (DLP); 3) NTIS; and 4) National Archives and Records Administration (NARA). These agencies realize the need for change, but have thus far failed to develop workable strategies for electronic STI. If they are to flourish in the unfolding electronic environment, GPO, DLP, NTIS, and NARA must become innovative, flexible, and competitive in anticipating and meeting electronic information needs.[13]

[12]Including the Superintendent of Documents (SupDocs), who administers cataloging, sales, international exchange, and depository library programs, among others.

[13]For background discussion, see U.S. Congress, Office of Technology Assessment, *Informing the Nation: Federal Information Dissemination in an Electronic Age*, OTA-CIT-396 (Washington, DC: U.S. Government Printing Office, October 1988). For pending legislation, see H.R. 3849, the "Government Printing Office Improvement Act of 1990," 101st Cong., 2d. sess., Jan. 23, 1990, which centrally addresses GPO and DLP; S. 1742, op. cit., footnote 10, and H.R. 3695, op. cit., footnote 10, which touch on GPO, DLP, and NARA; H.R. 4329, the "American Technology Preeminence Act,"

A Presidential STI initiative could focus attention on these important issues. **The list of designated presidential science and technology priorities, such as science education,[14] technology transfer,[15] high-performance computing and networking,[16] international competitiveness,[17] and global change,[18] justifies additional emphasis on STI.** STI is crucial to the success of each of these initiatives, starting with the role of STI in science education.

Low-cost, user-friendly electronic STI could stimulate computer-based science, mathematics, and engineering education. Pilot projects here and abroad indicate that junior and senior high school students (and even some in the elementary grades) can handle electronic databases as part of the science curriculum. Computer-based STI can help capture the interest, imagination, and enthusiasm of students through "hands-on" science that could improve the quality of science education.

Improving the "information literacy" of scientists and engineers must go hand-in-hand with upgrading STI; otherwise, the best STI systems will fall short. By integrating STI access, retrieval, and use into science education at all levels, the research skills and productivity of U.S. scientists and engineers could be strengthened in the long-term.

footnote 13 continued

101st Cong., 2d. sess., introduced and ordered to be reported by the House Committee on Science, Space, and Technology, Mar. 21, 1990, which addresses NTIS modernization, indexing, and electronic dissemination; statements of Fred B. Wood, OTA, and other witnesses before a Mar. 7-8, 1990, hearing on H.R. 3849 by the House Committee on Administration, Subcommittee on Procurement and Printing; statements of Fred B. Wood, OTA, and other witnesses before a Mar. 8, 1990, hearing on NTIS modernization by the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology; OTA and other comments provided on S. 1742 in connection with a Feb. 21-22, 1990, hearing of the Senate Committee on Govermental Affairs; statements of Joseph E. Jenifer, Acting Public Printer, and other witnesses before a Feb. 7, 1989, hearing of the House Committee on Appropriations, Subcommittee on the Legislative Branch, a May 23, 1989, hearing of the Committee on House Administration, Subcommittee on Procurement and Printing, and a July 11, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture; and the statement of Robert Houk, Public Printer, before an Apr. 6, 1990, hearing of the Senate Committee on Appropriations, Subcommittee on the Legislative Branch. Also see U.S. Congress, House, Committee on House Administration, Subcommittee on Procurement and Printing, *Title 44 U.S.C.—Review*, Hearings, 101st Cong., 1st sess., May 23 and 24, and June 28 and 29, 1989 (Washington, DC: U.S. Government Printing Office, 1989), and U.S. Congress, House, Committee on Science, Space, and Technology, *American Technology Preeminence Act*, Report 101-481, Part 1, to accompany H.R. 4329, 101st Cong., 2d sess. (Washington, DC: U.S. Government Printing Office, 1990).

[14]For background discussion, see American Association for the Advancement of Science, *Science for All Americans: Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology* (Washington, DC: 1989); U.S. National Research Council, *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (Washington, DC: National Academy Press, 1989); and U.S. Congress, Office of Technology Assessment, *Educating Scientists and Engineers: Grade School to Grad School*, OTA-SET-377 (Washington, DC: U.S. Government Printing Office, June 1988), and *Power On! New Tools for Teaching and Learning*, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988).

[15]For related discussion, see U.S. Congress, Office of Technology Assessment, *Technology and the American Economic Transition: Choices for the Future*, OTA-TET-283 (Washington, DC: U.S. Government Printing Office, May 1989), *Holding the Edge: Maintaining the Defense Technology Base*, OTA-ISC-420 (Washington, DC: U.S. Government Printing Office, April 1989), and *Arming Our Allies: Cooperation and Competition in Defense Technology*, OTA-ISC-449 (Washington, DC: U.S. Government Printing Office, May 1990). Also see H.R. 4653, the "Export Facilitation Act of 1990," 101st Cong., 2d sess., Apr. 26, 1990, ordered to be reported by the House Committee on Foreign Affairs, May 10, 1990.

[16]For discussion, see S. 1067, the "High-Performance Computing Act of 1990," 101st Cong., 1st sess., May 18, 1989, ordered to be reported by the Senate Committee on Commerce, Science, and Transportation, Apr. 3, 1990; H.R. 3131, the "National High-Performance Computer Technology Act of 1989," 101st Cong., 1st sess., Aug. 3, 1989; H.R. 4329, Title VII, the "National High-Performance Computer Technology Program Act of 1990," 101st Cong., 2d sess., introduced and ordered to be reported by the House Committee on Science, Space, and Technology, Mar. 21, 1990; U.S. Congress, Office of Technology Assessment, *High Performance Computing & Networking for Science*, OTA-BP-CIT-59 (Washington, DC: U.S. Government Printing Office, September 1989); and Executive Office of the President, Office of Science and Technology Policy, *The Federal High Performance Computing Program*, Sept. 8, 1989.

[17]For related discussion, see U.S. Congress, Office of Technology Assessment, *Making Things Better: Competing in Manufacturing*, OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, February 1990) and *Critical Connections: Communication for the Future*, OTA-CIT-407 (Washington, DC: U.S. Government Printing Office, January 1990).

[18]See, for example, the discussion of global change data management needs in U.S. Federal Coordinating Council for Science, Engineering, and Technology, Committee on Earth Sciences, *Our Changing Planet: The FY 1990 Global Change Research Plan* (Washington, DC: Office of Science and Technology Policy, July 1989), pp. 91-99; and U.S. National Aeronautics and Space Administration, Earth Systems Science Committee, *Earth Systems Science: A Closer View* (Washington, DC: NASA, January 1988).

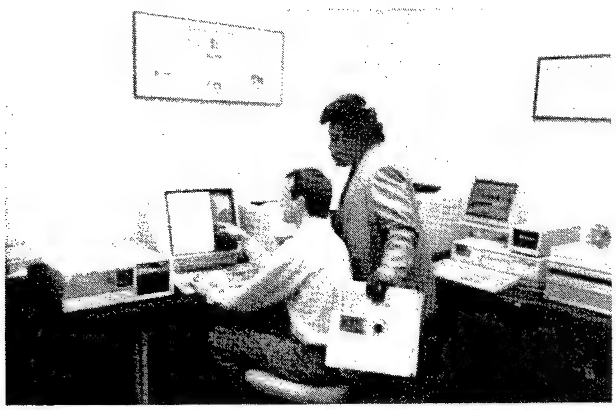

Photo credit: Office of Scientific and Technical Information, DOE

The Department of Energy's Office of Scientific and Technical Information is implementing information systems that use magnetic, optical, and online electronic technologies. DOE alone generates about 30,000 technical documents and articles per year; the governmentwide volume is about 200,000 items annually. New technologies are essential to cope with the burgeoning scientific and technical literature; for example, one double-sided 12-inch WORM can store about 1.2 million text pages or 6,000 technical documents (at 200 pages each).

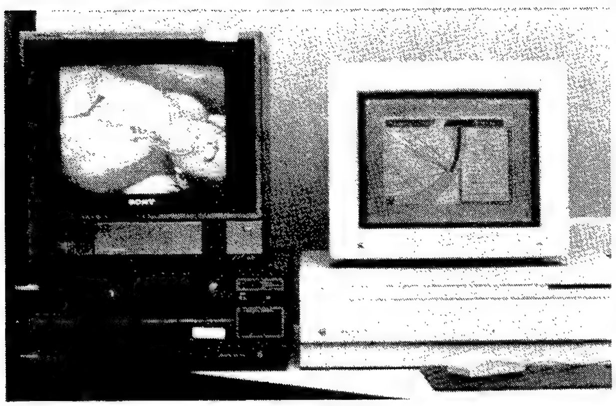

Photo credit: National Library of Medicine

This "Electronic Cardiology Textbook" represents the state-of-the-art in the use of electronic imaging to communicate scientific and technical information. The "textbook" stores images and sounds of the human heart on an optical disk; the user turns the pages electronically with a mouse and microcomputer.

Photo credit: Government Printing Office

Online information networks serve several important needs of the scientific and technical community. GPO uses an online system, shown here, to receive documents from remote locations; users simply "dial-up" the GPO system and transmit their material to GPO for processing. Online networks are used by several Federal science agencies to transmit documents, data, and messages; search bibliographic databases; transfer large streams of data; and remotely access large-scale high-performance computers.

Chapter 2

Federal Scientific and Technical Information and the U.S. Competitive Edge

The drumbeat of political, economic, and environmental change around the world presents the United States with perhaps its greatest challenge since World War II. The global society is more competitive with respect to scientific and technological achievement, educational attainment, market development, and political leadership in addressing international issues. This Special Report examines in detail one key element in restoring U.S. competitive strength—the role of scientific and technical information (STI) developed by or for the Federal Government.

The importance of STI stems from its critical role in all phases of the innovation process. These include education, basic research, applied research and development, product development and manufacturing, and the application of science and technology to meet the needs in the commercial, not-for-profit, and governmental markets.

STI and Science and Technology Policy

STI policy is a component of overall Federal science and technology (S&T) policy. The latter includes the range of Federal actions that can influence the conduct of U.S. research and development (R&D) and conversion of R&D results into products and services to satisfy domestic needs and compete with foreign suppliers. Federal S&T policy is diverse, and includes: direct Federal funding (e.g., for basic research); the conduct of research in Federal laboratories; tax incentives for private sector R&D (e.g., accelerated depreciation and tax credits for technology investments); and rules or guidelines to waive antitrust laws for industry R&D consortia, among others; as well as policies and actions for collecting and disseminating STI.

This Special Report focuses primarily on the STI component of Federal science and technology policy. Related OTA studies address other aspects of S&T policy.[1] STI is an indispensable part of the R&D infrastructure. But more than that, it is a national asset that can contribute to strengthening the technological foundation of the U.S. economy. Debates may rage over the role of the Federal Government in promoting industrial competitiveness. But clearly it is incumbent on the government to improve the STI base on which many public and private R&D decisions are made. The challenge is to help STI more fully serve national priorities.

STI frequently has been lost in the broader debates over: U.S. technology policy; the role of science advice in the White House; and, in recent years, the need for and shape of a national information policy.[2] During the 1980s, the case for STI has been bolstered by considerable research (discussed later in this chapter) that has documented the role of STI in priming the pump of R&D and innovation. STI is, indeed, at the heart of the process by which science generates new ideas that in turn fuel technological innovation. The concern over U.S. competitiveness gives new impetus to the need for a sound STI policy.

Discussions of U.S. competitiveness typically are dominated by the international economic dimension, i.e., the ability of U.S. companies to compete

[1]See the ongoing U.S. Congress, Office of Technology Assessment studies, "Basic Research for the 1990s," scheduled for completion in winter 1991, and "Information Research and Technology: High Performance Computing and Networking for Science," scheduled for completion in fall 1990. Also see, for example, Office of Technology Assessment, *The Regulatory Environment of Science*, OTA-TM-SET-34 (Washington, DC: U.S. Government Printing Office, February 1986); *Technology and the American Economic Transition: Choices for the Future*, OTA-TET-283 (Washington, DC: U.S. Government Printing Office, May 1988); *Educating Scientists and Engineers: Grade School to Grad School*, OTA-SET-377 (Washington, DC: U.S. Government Printing Office, June 1988); *Holding the Edge: Maintaining the Defense Technology Base*, OTA-ISC-421 (Washington, DC: U.S. Government Printing Office, April 1989); *High Performance Computing & Networking for Science*, OTA-BP-CIT-59 (Washington, DC: U.S. Government Printing Office, September 1989); *Computer Software and Intellectual Property*, OTA-BP-CIT-61 (Washington, DC: U.S. Government Printing Office, March 1990); and *Making Things Better: Competing In Manufacturing*, OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, February 1990).

[2]See, for example, J.M. Logsdon, "Toward a New Policy for Technology: The Outline Emerges," *Technology Review*, October/November 1972, pp. 36-42; U.S. Department of Commerce, Office of the Assistant Secretary for Science and Technology, *U.S. Technology Policy: A Draft Study* (Washington, DC: National Technical Information Service, March 1977); U.S. Congress, Office of Technology Assessment, *Computer-Based National Information Systems: Technology and Public Policy Issues*, OTA-CIT-146 (Washington, DC: U.S. Government Printing Office, October 1981); C.R. McClure and P. Hernon, *United States Scientific and Technical Information: Views and Perspectives* (Norwood, NJ: Ablex Publishing Corp., 1989).

STI is an indispensable part of the R&D infrastructure. But more than that, it is a national asset that can contribute to strengthening the technological foundation of the U.S. economy.

effectively in the international marketplace. STI is multidimensional and involves a "life cycle" approach to competition ranging from education to research to manufacturing to marketing and public policy. When viewed in a total competitive context, STI is the backbone of our competitive edge.

STI is linked with several national goals. STI resulting from Federal R&D is intended to promote the advancement of scientific knowledge and technical applications of that knowledge. It also serves other national goals, including: improving the ability of U.S. industrial firms to compete in the international economy; strengthening the U.S. defense and civilian technology base; improving U.S. science and engineering education; promoting international cooperation on global science and technology-related problems; and enhancing the free flow of STI required by an open, democratic society.

America's ability to achieve these national goals in part through STI has been limited by our inability to clearly define the contribution of STI to these goals and to reconcile the conflicts over competing goals that inevitably arise. The policy framework for STI dissemination must recognize and spell out the role of STI at each stage of education, research, and application. For example, STI about solar photovoltaic energy can be structured in terms of what is needed for: educating future solar energy scientists and engineers; supporting basic research on the physics and electronics of photovoltaic energy; facilitating applied research on photovoltaic cells; enhancing the development of prototype and commercial photovoltaic energy systems, and the manufacturing technology for production of such systems; encouraging the integration of photovoltaics into U.S. commercial and defense energy applications; and informing the national and international debate on alternative energy and environmental policies.

The U.S. competitive challenge is epitomized by the so-called "technology-intensive" industrial sectors, such as computers, telecommunications, electrical machinery, instruments, chemicals, and transportation. These sectors have been the mainstays of the U.S. post-World War II economy, due to high rates of growth in real output, productivity, and employment, and for many years contributed to a positive trade balance. Recently, even the strongest U.S. industrial sectors have come under intensified competition. This is due in part to the rise of the global economy and dominance of multinational companies (that operate across national boundaries), the continuing Federal budget deficit and negative trade balance and resulting effects on international monetary exchange rates, and the partially offsetting growth of the service sectors (where the United States competes strongly in some areas, notably information services). But the new competitive realities have spurred attention to other root causes.[3]

In a world of rapid technological change, successful competition is driven as much by the information skills of the work force and by the timing of information access, as it is by the brute intellectual, financial, and natural resources of the competitors. Scientific and technical advancements are information-intensive, and those who know how to obtain and use STI will have a competitive edge—whether the competition is over market share or over intellectual leadership on global issues.

In this context, the role of electronic technologies takes on significance, since the generation, location,

STI is multidimensional and involves a "life cycle" approach to competition ranging from education to research to manufacturing to marketing and public policy. When viewed in a total competitive context, STI is the backbone of our competitive edge.

[3]For a comprehensive analysis, see U.S. Congress, Office of Technology Assessment, *Technology and the American Economic Transition: Choices for the Future*, OTA-TET-283 (Washington, DC: U.S. Government Printing Office, May 1988); and OTA, *International Competition in Services*, OTA-ITE-328 (Washington, DC: U.S. Government Printing Office, July 1987).

Scientific and technical advancements are information-intensive, and those who know how to obtain and use STI will have a competitive edge—whether the competition is over market share or over intellectual leadership on global issues.

and retrieval of STI can be vastly speeded up.[4] STI users need to be better educated about how Federal (and other) STI may help, how and where Federal (and other) STI may be accessed, and use of the tools that facilitate access (e.g., online databases, compact optical disks, and bibliographic and search and retrieval software). And science agency managers need to do a better job at including STI dissemination and use as integral parts of agency R&D programs.

STI and Science Education

Science and technical education is the foundation for the technological and economic competitive posture of the United States. Congress in enacting the "Education and Training for a Competitive America Act of 1988" noted:[5]

- "our [Nation's] standing in the international marketplace is being further eroded by the presence in the workforce of millions of Americans who are functionally or technologically illiterate or who lack the mathematics, science, foreign language, or vocational skills needed to adapt to the structural changes in the global economy;
- "our competitive position is also being eroded by declines in the number of students taking advanced courses in mathematics, science, and foreign languages and by the lack of modern technical and laboratory equipment in our educational institutions;
- "restoring our competitiveness and enhancing our productivity will require that all workers possess basic educational skills and that many others possess highly specific skills in mathematics, science, foreign languages, and vocational areas."

Recent OTA studies have identified a wide range of actions to improve science education: upgrade the quality of elementary, secondary, and higher education with respect to science and engineering; increase student interest in science and engineering; and expand the number of science and engineering students (and ultimately the pool of trained scientists and engineers).[6]

Several of these actions relate directly to Federal STI. For example, OTA found that "hands-on" computer-based science learning can increase student interest in the subject matter and enhance student learning. OTA also noted the growing role of computer-based science in science museums, science centers, and science fairs around the country. Overall, availability of Federal STI in low-cost, user-friendly electronic formats could add an important dimension to computer-based mathematics, science, and engineering education. School libraries can serve as a focal point for teacher and student training in the use of online and compact optical disk media, and can provide a shared computer resource available to support the science curriculum.[7] This could be an extension of the role already performed by library staff at many college and university libraries and at some of the larger and better-funded public libraries. In general, strong library media programs at the elementary and secondary levels

[4]See, for example, J. Bortnick and N.R. Miller, *The Impact of Information Technology on Science* (Washington, DC: Congressional Research Service, July 1985); National Academy of Sciences, Committee on Science, Engineering, and Public Policy, *Information Technology and the Conduct of Research* (Washington, DC: National Academy Press, 1989); and U.S. Congress, Office of Technology Assessment, *High Performance Computing and Networking for Science*, OTA-BP-CIT-59 (Washington, DC: U.S. Government Printing Office, September 1989).

[5]Public Law 100-418, the "Omnibus Trade and Competitiveness Act of 1988," 100th Cong., 2d sess., Aug. 23, 1988, Title VI—Education and Training for American Competitiveness, sec. 6002(a)(3-5).

[6]See U.S. Congress, Office of Technology Assessment, *Educating Scientists and Engineers: Grade School to Grad School*, OTA-SET-377 (Washington, DC: U.S. Government Printing Office, June 1988); *Power On! New Tools for Teaching and Learning*, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988); *Elementary and Secondary Education for Science and Engineering*, OTA-TM-SET-41 (Washington, DC: U.S. Government Printing Office, December 1988); and *Higher Education for Science and Engineering*, OTA-BP-SET-52 (Washington, DC: U.S. Government Printing Office, March 1989).

[7]See, for example, J.W.Leisner, "Learning at Risk: School Library Media Programs in an Information World," *School Library Media Quarterly*, Fall 1985, pp. 11-20; B.K. Stripling, "Rethinking the School Library: A Practitioner's Perspective," *School Library Media Quarterly*, Spring 1989, pp. 136-139.

School libraries can serve as a focal point for teacher and student training in the use of online and compact optical disk media, and can provide a shared computer resource available to support the science curriculum.

correlate with improved student skills in use of library and information resources, and in student achievement both overall and in specific science subjects.[8]

Pilot projects have shown that junior and senior high school students can readily handle computer-based bibliographic searches as an aid to course-work.[9] Teachers concluded that database searching enhanced student thinking and research skills. Online searching was also used to augment the science education curriculum. For example, students conducted online searches on topics such as the Armenian earthquake, space sickness, and the climatic effects of tropical deforestation.

Integrating STI access, retrieval, and use into science education at all levels could improve the research skills and productivity of U.S. scientists and engineers in the long term. Various studies have highlighted the "inadequate information gathering and management skills of the R&D community" and the lack of skills and/or motivation to use available bibliographic tools.[10] Electronic dissemination of Federal STI could assist in attacking this problem.

Improving the "information literacy" of U.S. scientists and engineers must go hand-in-hand with upgrading STI. Even the best STI system would fall short if the users lack the skills to search bibliographic databases, retrieve and manipulate data, and scan documents. In many fields of science and technology, STI developed by other countries is increasingly important. Foreign patents now account for about 50 percent of all U.S. patents. The number of foreign scientific journals and articles is growing much faster than those published in the United States.[11] U.S. researchers must learn to utilize foreign STI, while making better use of domestic STI. The experience with Japanese STI suggests that U.S. researchers are, by and large, not well-trained in foreign languages and, generally, in techniques for accessing and utilizing foreign STI, and largely fail to recognize the need for doing so.[12]

STI and Research and Development

The creation of new information and knowledge is the major objective of R&D. This information takes many forms: information from basic research on AIDS conducted by Federal laboratories; design and testing of prototype photovoltaic solar energy cells by the Department of Energy (DOE); or the synthesis of satellite data collected by the National Oceanic and Atmospheric Administration (NOAA) to improve understanding of the interaction of the atmosphere and oceans in climate change.

Scientists and engineers involved in R&D often spend between one-quarter and one-half of their time

[8]See J.C. Mancall, "An Overview of Research on the Impact of School Library Media Programs on Student Achievement," *School Library Media Quarterly*, Fall 1985, pp. 33-36.

[9]See, for example, M.H. Bailey, J. Wieman, J. Newman, and N. Motomatsu, *Research Goes to School II: How To Go Online to the Information Databases* (Olympia, WA: Know-Net Dissemination Project, 1985); and N. Motomatsu and J.A. Newman, *Research Goes to School III: Going Online With Students* (Olympia, WA: Office of the Superintendent of Public Instruction, 1986). In Australia, a recent survey identified 20 schools (2 primary and 18 secondary) using online systems "as a source of up-to-date information for teachers and students and as a means of helping students to acquire information skills." See L.A. Clyde and J. Kirk, "The Use of Electronic Information Systems in Australian Schools: A Preliminary Survey," *School Media Library Quarterly*, Summer 1989, pp. 193-199. In the United States, the Oakland County (Michigan) School District has successfully piloted the use of online bibliographic databases available from a commercial vendor. Students, teachers, and administrators from the participating schools (3 junior high and 3 high schools) enthusiastically embraced online searching. See Oakland County Schools, Educational Resource Center, "Database Searching Pilot Project," Pontiac, MI, Nov. 9, 1989.

[10]See C.R. McClure, "Increasing Access to U.S. Scientific and Technological Information: Policy Implications," ch. 12 in C.R. McClure and P. Hernon, *United States Scientific and Technical Information Policies: Views and Perspectives* (Norwood, NJ: Ablex Publishing Corp., 1989), pp. 319-354.

[11]See D.W. King, D.D. McDonald, and N.K. Roderer, *Scientific Journals in the United States: Their Production, Use, and Economics* (Stroudsburg, PA: Hutchinson Ross Publishing Co., 1981).

[12]See C.T. Hill, *Japanese Technical Information: Opportunities To Improve U.S. Access*, Report No. 87-818 (Washington, DC: Congressional Research Service, Oct. 13, 1987); C.T. Hill, "Federal Technical Information and U.S. Competitiveness: Needs, Opportunities, and Issues," *Government Information Quarterly*, vol. 6, No. 1, 1989, pp. 31-38.

on information-related activities that include both analyzing and reporting on one's own research and searching for and applying the research results of others. Researchers in most disciplines spend about 15 to 20 percent of their time just on reading the STI literature, including scholarly journal articles, conference proceedings, and technical reports.[13] Researchers also find relevant STI through participation in technical conferences and activities of professional and scientific societies, and through informal letters, meetings, conversations, and, recently, electronic mail and bulletin boards.

Scientists and engineers involved in R&D often spend between one-quarter and one-half of their time on information-related activities that include both analyzing and reporting on one's own research and searching for and applying the research results of others.

Roughly three-quarters of researchers access STI literature in order to apply other research findings to a current project and/or for professional development or current awareness of STI trends. About half of the researchers read the STI literature to help prepare an article, book, or report, and about two-fifths to help prepare a lecture or presentation.[14] Not surprisingly, empirical research in a range of government and private-sector settings has found that reading STI is positively correlated with productivity (e.g., number of reports or publications written and presentations delivered).[15]

DOE estimates that federally funded energy researchers spend, collectively, the equivalent of over $1 billion per year of their time on STI (out of an annual R&D budget of over $5 billion). This is split about equally between generating new STI (e.g., writing technical reports) and reading other STI (e.g., journal articles), and amounts to roughly one-fifth of the total DOE R&D budget. In addition, DOE spends about $250 million annually on STI information management, libraries, technical information centers, and other STI-related activities. If the DOE estimate is extrapolated to the entire Federal R&D effort, then Federal researchers spend roughly 12 billion dollars' worth of time each year on STI.

The Department of Defense (DoD) has not made comparable estimates. But assuming that the roughly 180,000 scientists and engineers doing DoD-related research work spend an average of 10 hours per week on STI, the annual time investment is 144 million hours. If time is valued, conservatively, at $30 per hour, then DoD researchers spend at least $2.7 billion per year worth of their time on STI.[16] The actual figure is likely to be double or triple (e.g., $5 to $7 billion per year, which would be consistent with the DOE estimates), and even this would not include STI time spent in connection with DoD test, evaluation, maintenance, and operational activities.

This kind of investment in STI is essential to scientific advancement and technical innovation that are, in large measure, built on the cumulative knowledge base of the scientific and technical disciplines. Breakthroughs may come slowly or, on occasion, may occur quickly as a result of groundbreaking research, a new interdisciplinary synthesis, or a "paradigm shift" where the cumulative knowledge leads scientists to revise their basic hypotheses—e.g., with respect to the susceptibility of the Earth to global change, and the role of the oceans, land, glaciers and ice sheets, biota, and the atmosphere in climate change. Geology, glaciology, oceanography, and climatology are among the several scientific disciplines that benefit from and contribute to Federal R&D and STI. Likewise, rapid advances in our understanding of human health depend on the extensive exchange of STI among researchers in

[13] See N.K. Roderer, D.W. King, and S.E. Brouard, "The Use and Value of Defense Technical Information Center Products and Services," contractor report prepared by King Research, Inc. for the Defense Technical Information Center, Mar. 31, 1983, p. 20 and references cited therein. Also see E.R. Siegel, "Transfer of Information to Health Practitioners," in B. Dervin and M.J. Voight (eds.), *Progress in Communication Sciences, Vol. III* (Norwood, NJ: Ablex Publishing Corp., 1982), pp. 311-334.

[14] See, for example, Roderer et al., op.cit., footnote 13, p. 34.

[15] King Research Inc. has obtained similar results for numerous Federal and private-sector organizations. For a summary, see J.M. Griffiths and D.W. King, "Evaluating the Performance and Effectiveness of Information Services," paper prepared for the Mid-Atlantic Chapter, Medical Library Association, Rockville, MD, 1989.

[16] 180,000 persons × 10 hours spent on STI/week × 50 weeks/year (assuming 2 weeks vacation) × $30/hour = $2.7 billion. DoD officials have confirmed the 180,000 persons as a reasonable estimate.

disciplines such as biology, physiology, psychology, medicine, and nutrition.

Improving the use of STI could increase the return on the Federal Government's substantial investment in R&D, which is currently about $65 billion per year and represents roughly one-half of the total U.S. investment in R&D. Assessing the value of information dissemination services and products, whether Federal or otherwise, is obviously difficult. One technique is to estimate the savings (benefits) resulting from using an STI service or product. Using this approach, each dollar spent on Federal STI dissemination generates an estimated direct benefit of at least $2 to $5 to users in the research community (e.g., in terms of time saved, duplications avoided, etc.) and on occasion can reach into the hundreds to thousands of dollars.[17] Online databases are especially highly leveraged. If the cost of originating the information is not included (presumably funded out of Federal R&D funds), some databases generate an estimated value (savings or benefit in the eyes of the user) of $15 to $25 for each dollar spent.[18] This helps explain why many online users readily pay $15 to $25 per hour for online access to government databases (and up to $150 to $200 per hour for commercial databases).

Users of technical reports from DOE's Office of Scientific and Technical Information indicate significant savings for each report used, and that about 75 percent of reports used yield some savings.[19] Some typical examples of specific savings are:

- A basic energy sciences researcher saved over $50,000 by obtaining STI that eliminated the need to do a complete design from scratch of a double-effect absorption cooling system.
- A health and environment researcher saved $5,000 through STI that mooted the requirement for certain tests on disposal of wastewater from coal conversion.
- A fusion researcher saved a person-year of effort through STI that summarized prior related research on ion beam propagation and focusing.
- A nuclear researcher saved $1,000 through STI that provided calculations—that would otherwise have had to be redone—on steam electronic plant construction.

The benefits and savings from effective use of Federal STI include:

- time saved in locating other researchers doing related work;
- time and money saved in minimizing duplication of research effort;
- new insights or breakthroughs resulting from more complete awareness of related research;
- new information not available elsewhere;
- better understanding of relevant Federal R&D directions; and
- time and money saved in writing research reports, papers, and articles.

Federal science agencies face a major challenge in managing the already immense and rapidly increasing volume of Federal STI so that it is accessible and useful to researchers. For example, over 200,000 new technical documents are generated each year as a result of Federal R&D, adding to the base of an estimated 4 million existing documents.[20] Satellite data and imagery are contributing to an STI explosion in the space and earth sciences. The total earth sciences data volume managed by Federal agencies (primarily NASA, USGS, and NOAA) is roughly 100,000 gigabytes.[21] The total volume is projected to increase by two orders of magnitude over the next 5 to 10 years to 10 million gigabytes (or 10,000

[17]See Roderer et al., op. cit., footnote 13; and D.W. King, J.M. Griffiths, N.K. Roderer, and R.R.V. Wiederkehr, "Value of the Energy Data Base," contractor report prepared by King Research, Inc. for the U.S. Department of Energy, Mar. 31, 1982.

[18]For a good summary of relevant research issues and results, see B.C. Carroll and D.W. King, "Value of Information," *Drexel Library Quarterly*, vol. 21, No. 3, Summer 1985, pp. 39-60.

[19]Ibid. The average savings per report was $1,300 (1982 dollars).

[20]The Department of Energy (DOE) has generated a cumulative total of about 800,000 technical documents that are estimated to represent about one-fifth of the governmentwide total. The National Technical Information Service (NTIS) clearinghouse includes about 2 million technical reports, estimated to represent about one-half of the governmentwide total. DOE generates about 30,000 new technical documents each year, estimated to be 15 percent of the governmentwide total; NTIS adds about 65,000 new documents to its clearinghouse each year, estimated to represent about one-third of the governmentwide total. These estimates are for technical documents and articles published in the technical literature, but exclude papers delivered at technical conferences. For DOE, the annual volume of technical articles equals that of technical documents (about 15,000 each).

[21]One gigabyte is equivalent to the volume of information contained in about 450,000 double-spaced typed pages of text. One terabyte equals 1,000 gigabytes or 1 trillion bytes; 100,000 gigabytes equals 100 terabytes. The current and projected earth sciences data volumes are based on estimates by the Interagency Working Group on Data Management for Global Change.

terabytes). When launched in the late 1990s, NASA's Earth Observing System (EOS) will generate in a few months more data than the total U.S. archive of Landsat satellite data collected over the last 18 years.

Electronic technologies can help the Federal science agencies manage STI and ensure that Federal data and documents are made available to users in cost-effective, timely, and usable form. The potential for electronic STI dissemination is especially great because—whether data, documents, or directories to data or documents—it is generally well suited to electronic formats. Electronic dissemination makes it possible to provide STI to researchers in forms that are more convenient to retrieve and easier to manipulate. This could enable many potential new kinds of research and analysis. (See the appendix for a detailed discussion of technological opportunities.)

STI and Product Development and Manufacturing

STI is also a key element in the transfer of technology from the laboratory to the production line. The aerospace industry is a case in point. It is supported by a substantial Federal R&D investment, it has close collaboration with Federal agencies (civilian and military), industry, and academia, and it has a tradition of aggressively using the results of Federal aerospace R&D in commercial applications. A recent survey of aerospace engineers sheds light on the dominant role of STI in an industry with a successful track record of commercialization and international competition.[22]

Ninety percent of the aerospace engineers identified technical communication as very important. On the average, respondents spend about 35 percent of their workweek communicating technical information to others and about 31 percent of their week working with technical information received from others. Based on a 40-hour workweek, they spend roughly 26 hours on STI-related activities, a finding consistent with other studies.[23] These engineers produce on the average 1.6 government technical reports and 1.9 other technical reports every 6 months and use roughly 52 technical reports (about half generated from Federal R&D) during that time.

The aerospace industry has been successful at commercial utilization of Federal R&D because, for many decades, both government and industry have recognized the importance of Federal R&D and the highly leveraged role of STI and technology transfer mechanisms in the commercialization process. The National Aeronautics and Space Administration (NASA) has long-established relationships with academia and industry to encourage the use of STI. NASA has established a network of Industrial Application Centers as part of its Technology Utilization Program. The centers provide technical information to industry so that aerospace technology can be used in commercial applications. The effectiveness of this approach is illustrated by these examples:[24]

- A Western Springs, Illinois, firm specializing in high-resolution, oblique, aerial photography requested that NERAC research the NASA database for available information on film and cameras. Using the technology provided by NERAC, the firm improved the quality of its aerial photographs, which now sell for upwards of $2,000 each.
- A New York firm designed a computer-controlled robot using NERAC technology from its NASA database. NERAC rapidly gathered information on robot off-line programming methodology so that the firm's R&D staff could implement the concept by using a microcomputer system and graphics display.
- A firm dedicated to the development and manufacturing of testing equipment requested that NERAC research noise control technology. The search identified technical information that led to the development of a very high-performance hearing protector (with over 34 dBA of insulation) that will be marketed for

[22]T.E. Pinelli, M. Glassman, W.E. Oliu, and R.O. Barclay, *Technical Communications in Aeronautics: Results of an Exploratory Study*, NASA Technical Memorandum 101534, Part 1 (Hampton, VA: U.S. National Aeronautics and Space Administration, Langley Research Center, February 1989). The survey instrument was sent to 2,000 randomly selected aerospace scientists and engineers (from the membership of the American Institute of Aeronautics and Astronautics). The response rate was 30.3 percent (606 out of 2,000). The affiliations of respondents were distributed as follows: academic (7%); industry (62%); not-for-profit (3%); NASA (12%); other government (16%). The professional duties of the respondents were: research (20%); administration/management (24%); design/development (37%); teaching/academic (6%); marketing/sales (6%); and other (7%).

[23]See Pinelli et al., op. cit., footnote 22; R.M. Davis, *Technical Writing: Its Place in Engineering Curricula—A Survey of the Experience and Opinions of Prominent Engineers*, Air Force Institute of Technology Technical Report 75-5 (Wright-Patterson Air Force Base, OH: September 1975).

[24]Provided by one of the oldest Industrial Application Centers, NERAC, Inc.

use on aircraft flight lines, in airports, at rifle/pistol ranges, etc.—anyplace where full noise protection is required.

- A firm designed a water distillation system using solar energy, based in part on technical information provided by NERAC. The concentration of the Sun's rays causes a thermal reaction which initiates a distillation process that results in water vaporization. The water vapor is distilled and collected as a usable product. The solar system is expected to provide low-cost, fresh water supplies to remote, arid, and coastal towns.

Engineers rely more on their own knowledge and contacts with colleagues and inhouse experts to solve technical problems than on technical reports, journals, libraries, technical information centers, or online technical information databases. The 1989 NASA survey of aeronautical engineers confirmed the same pattern revealed in numerous other studies—personal, informal sources take precedence over the more formal, organized information sources.[25]

Engineers are likely to continue to rely in the first instance on personal, informal information sources. But there are significant opportunities to improve the effectiveness of technical reports, libraries, information centers, and computerized databases. For example, at present, less than half of aerospace engineers (44 percent, based on the NASA survey[26]) use electronic databases at all, and less than half (46 percent[27]) use a library or technical information center more than once a month. When electronic databases are searched, about two-thirds of the engineers use intermediaries (e.g., reference librarians) to perform the search. Engineers are generally open to the use of new information technologies. The four technologies receiving the highest percentage of "I don't use it, but may in the future" in the NASA survey are:[28]

- laser disk/videodisk/compact optical disk (65 percent);
- videoconferencing (62 percent);
- electronic bulletin boards (54 percent); and
- electronic networks (53 percent).

Data on physical and chemical properties of materials are another form of STI that is important to industrial technology. The technical design of automobiles through electronic equipment must comport with a wide range of so-called "standard reference data" on the basic properties of materials and industrial processes used in manufacturing. The accuracy of this data is essential. Engineers include a margin of safety in product and process designs, but if faulty design data are used, the product or process could fail under certain operating conditions.

The Federal Government plays a major role in developing, maintaining, and updating standard reference data. This is accomplished through research conducted in Federal laboratories, Federal support for university and industrial research, government-industry cooperative initiatives, and Federal participation in a wide range of professional and technical standards activities. Topics range from radiation chemistry to thermodynamics to metallurgy to electronic properties to microwave spectral data.[29]

Private-sector managers recognize that the "cost of not knowing" can be very high. Employees can work hard, but if they do not work "smart," the result can be losses instead of profits—whether conducting research, competing for a Federal R&D contract, or selling a safe, reliable, and competitive product in the marketplace.

STI plays a crucial role in the commercialization process by which the results of Federal and private R&D are translated into marketable products. The challenge is to increase the return on the Federal

[25]See Pinelli et al., op.cit., footnote 22, p. 56; T.J. Allen, *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information Within the R&D Organization* (Cambridge, MA: MIT Press, 1977); H.L. Shuchman, *Information Transfer in Engineering* (Glastonbury, CT: The Futures Group, 1981); S. Ballard, C.R. McClure, T.I. Adams, M.D. Levine, L. Ellison, T.E. James, Jr., L.L. Malysa, and M. Meo, *Improving the Transfer and Use of Scientific and Technical Information: The Federal Role* (Norman, OK: University of Oklahoma, Science and Public Policy Program, 1986).

[26]Pinelli et.al., op.cit., footnote 22, p. 66.

[27]Ibid., p. 65.

[28]Ibid., p. 73.

[29]The National Research Council's Numerical Data Advisory Board (recently renamed the Scientific and Technical Information Board) has issued many relevant reports. For references, see National Research Council, Numerical Data Advisory Board, *Improving the Treatment of Scientific and Engineering Data Through Education* (Washington, DC: National Academy Press, 1986). Also see minutes of the Sept. 21, 1989, NDAB meeting available from C. Carter, staff director, NRC/NDAB, 2101 Constitution Ave., N.W., Washington, DC 20418.

R&D investment through more effective utilization of the STI resulting from Federal R&D. This can be achieved by several means, including: improving the usability of government technical reports (e.g., formats, indexing, electronic retrieval); strengthening the capabilities of libraries and information centers to meet STI needs; sharpening the skills of scientists and engineers in using these resources; and continually upgrading the ability of technology-enhanced STI systems (e.g., online, compact optical disk) to provide affordable, user-friendly search and retrieval service. This is a challenge demanding the combined efforts of government, industry, academia, and the broader scientific and technical community.

STI and International Leadership on Global Issues

Another part of the competitive edge—in addition to education, R&D, and commercialization—is the ability of the United States to provide international leadership on a wide range of global problems. Providing and exchanging STI are important components of such leadership. The challenge is to maintain and strengthen the open flow of relevant STI in the face of greatly intensified global economic competition.

The United States has substantial information assets, and these are being augmented by use of electronic avenues of dissemination. A case in point is the MEDLINE (MEDLARS—Medical Literature Analysis and Retrieval System—online) database developed by the National Library of Medicine and offered online by NLM and several commercial vendors to the U.S. and foreign medical communities. MEDLINE is used for a wide variety of patient care, research, teaching, and administrative purposes.

Surveys indicate that MEDLINE is having a significant effect on medical decisions.[30] Physicians use MEDLINE information to select the most appropriate tests and diagnose a wide range of medical problems in order to prescribe a treatment plan. MEDLINE's successes are well-known.[31] For example, a pathologist examining a supposed "wart" used MEDLINE to confirm a diagnosis of skin cancer (polypoid melanoma) and develop a treatment plan. A physician treating an adolescent patient who collapsed during a foot race used MEDLINE to rule out exercise-induced pancreatitis as a possible cause, and prescribed rest and abstinence from food (which worked). And a physician used MEDLINE to locate information in a Swiss journal about a new treatment for aplastic anemia.

STI plays a crucial role in the commercialization process by which the results of Federal and private R&D are translated into marketable products. The challenge is to increase the return on the Federal R&D investment through more effective utilization of the STI resulting from Federal R&D.

Medical problems and research know no national boundaries, and the effectiveness of databases such as MEDLINE depends on international collaboration in the collection and exchange of medical information. Computerized databases have become essential to this process, with both NLM and private vendors making global electronic access possible. User-friendly microcomputers are bringing access to MEDLINE to the grassroots. In the United States, medical personnel can access MEDLINE using "Grateful Med," a search and retrieval software package developed by NLM and sold by the National Technical Information Service (NTIS) for $29.98 per copy. Grateful Med runs on IBM-compatible and Apple Macintosh personal computers.

Another area of intensive Federal information activity with significant international implications is geographic information. Computerized geographic information systems ("GIS") make it possible to access and manipulate large volumes of natural resource, environmental, geologic, and other spatially referenced data. A 1988 survey[32] identified 35

[30] S.R. Wilson, N. Starr-Schneidkraut, and M.D. Cooper, "Use of the Critical Incident Technique To Evaluate the Impact of MEDLINE," contractor report prepared by the American Institutes for Research for the National Library of Medicine, Bethesda, MD, Sept. 30, 1989.

[31] Ibid., see app. G, "Impact of the Information Obtained From MEDLINE on Medical Decision-Making."

[32] Federal Interagency Coordinating Committee on Digital Cartography, Reports Working Group, *A Summary of GIS Activities in the Federal Government*, August 1988, pp. 10-12.

Federal agencies with GIS applications, including, for example: the Agency for International Development (famine early warning, forestry); U.S. Forest Service (forest planning, gypsy moth suppression, fire behavior modeling); Soil Conservation Service (soil survey database, river basin and watershed planning, farm and ranch conservation planning); Census Bureau (all 1990 Census activities); NOAA/National Environmental Satellite Data Information Service (atlases showing geographic distribution of ice, drought, temperature, precipitation, sunshine, length of day, etc.); Bureau of Reclamation (land classification, irrigation monitoring, baseline habitat); and U.S. Geological Survey (earthquake hazard assessment, national mapping program, water quality monitoring). Transportation is another emerging area of major GIS application, especially with respect to renewing the U.S. surface and air transportation infrastructure.

GIS-based activities require much greater coordination among Federal, State, local, and international government agencies. While Federal agencies collect and/or develop a large amount of geographic information, State and local governments are among the heaviest users and also generate geographic information as well. The same is true for foreign governments and international intergovernmental bodies (e.g., the United Nations Environment Program and Food and Agriculture Organization). The range of international GIS applications is shown below:

1. *Preparation of thematic maps*, with data on the socioeconomic, demographic, soil, water, and other characteristics of defined geographic areas.
2. *Preparation of base maps*, including the plotting and revision of quadrangle maps, aeronautical charts, marine navigational charts, ocean surveys, and the like.
3. *Preparation of terrain maps*, including topographic, elevation, slope, relief, and perspective maps, among others.
4. *Data display and analysis*, including the presentation and manipulation of map data and the merging and integrating of map databases.
5. *Environmental assessment and monitoring*, including the use of geographic information in preparing environmental impact assessments and studies of irrigation, pollution, soil conservation, flood potential, and the like.
6. *Land and water resource planning and management*, including site and road designs, farm, forest, and wetland surveys, habitat and water quality studies.
7. *Mineral resource assessment*, including geographic maps, fuel and resource inventories, and geologic hazard analyses.
8. *Navigational systems*, including air traffic control systems and flight simulators.[33]

The role of STI and its dissemination varies depending on the area of science or technology. Historically, the Federal Government has encouraged the open exchange of Federal STI as a foundation of science and technology. Until recently, access to STI has been restricted only in narrowly defined areas of national security. This has been especially true in areas such as medicine and the environment, where health and safety considerations are paramount. But even in these areas, the changing competitive environment has led to increased sensitivity about open, international access to Federal STI (e.g., with respect to its use in commercialization of biotechnology, medical drugs and devices, or environmental mitigation techniques).

Over the last decade or so, intensified international technical and economic competition has led to additional restrictions on access to federally sponsored STI. These restrictions are based primarily on reasons of national security, foreign policy, and international competitiveness. Electronic technologies speed the transfer of information on national and global scales. Concern over this rapid, uncontrolled dissemination has fueled a debate over restrictions on access to STI.

This debate involves the balancing of competing interests. For example, in the area of export controls, the need to protect against export of militarily sensitive technologies and technical data directly or indirectly to U.S. adversaries must be balanced with the need to minimize adverse effects on international scientific exchange and on international trade opportunities. In domestic technology transfer, the need to encourage the transfer of technology (and related technical data) from the Federal Government to the private sector must be balanced with the need to

[33] Ibid.

minimize restrictions on access to unclassified Federal STI and promote a competitive marketplace (even though foreign companies may also benefit). Thus, the short-term interest of a solar energy company conducting Federal R&D must be weighed in the context of the long-term development needs of the U.S. solar energy industry as a whole and the interests of information vendors and users (e.g., librarians, entrepreneurs, policy analysts) who thrive on the open exchange of Federal STI.

In light of the political, military, and economic changes occurring in Europe and the Soviet Union, perhaps U.S. policies limiting the open flow of Federal STI should be reevaluated. It may be that the justifications for the restrictive approaches of the 1980s are less valid as the world reaches the last decade of the 20th century.[34] A key step in restoring the U.S. competitive edge is to build on the strengths of the U.S. governmental, academic, and commercial information sectors. Federal STI must play an important part in the overall U.S. competitiveness strategy.

STI and International Competitiveness: A Summation

On the one hand, the world is becoming much more competitive in political, economic, and technological terms. The moves toward political democracies and market-based economies will open up many new opportunities for U.S. firms trading overseas and for U.S. Government leadership on key international issues. However, these same opportunities will similarly be available to other nations. Markets and competition rely heavily on science, technology, and innovation.

Evidence shows that STI is very important to scientists, engineers, and managers in technology-intensive government agencies and industries.[35] Why? Because maintaining an information advantage is crucial to achieving a competitive edge. In the rapidly changing global marketplace of ideas and products, information has become an essential competitive resource—along with technology, capital, labor, and management.

The challenge for the United States is how to strengthen and deploy our own competitive STI assets. The Federal Government supports the largest R&D complex in the world, and generates the largest volume of STI. The United States has a strong educational and library infrastructure, and the U.S. commercial information industry is foremost in the world. Also, the United States is highly competitive in assembling the technical infrastructure (e.g., online and optical disk systems) necessary to deliver information products and services, including STI.

Yet the United States does not have an overall strategy to capitalize on these substantial assets, and to overcome its weaknesses, e.g., the training of scientists and engineers in STI search-and-retrieval skills, or the consideration of STI user's needs in science agency planning. To realize the potential of U.S. leadership in STI will require reaching a strong consensus on overall Federal STI policy.

The stakes are high, as measured by market size and private-sector and governmental activity:

- The Western European database services market is expected to double in the next 5 years, to over $7 billion, with the online portion projected to increase from 60 to 70 percent;
- The European Economic Community is sponsoring a wide range of pilot projects for the European information services market, including, for example, a multimedia atlas of the Mediterranean region on compact optical disk (that combines data, images, digital maps, and graphics on Mediterranean geography, agriculture, environment, and industry);
- Two private companies (one U.S., one foreign) are planning cooperative STI projects with the U.S.S.R. Academy of Sciences and State Committee for Science and Technology (including the establishment of training centers to teach STI online search skills to Soviet officials and scientists);

[34]The Federal Government is already reevaluating the need for controls on export of a variety of computer and telecommunications equipment and systems to the Eastern bloc; proposals to relax export restrictions are being discussed with the Coordinating Committee for Multilateral Export Controls (COCOM). Also see H.R. 4653, the "Export Facilitation Act of 1990," 101st Cong., 2d sess., Apr. 26, 1990, ordered to be reported by the House Committee on Foreign Affairs, May 10, 1990.

[35]For recent results on STI in the aerospace industry, see T.E. Pinelli, M. Glassman, R.O. Barclay, and W.E. Olin, *Technical Communication in Aeronautics: Results of an Exploratory Study—An Analysis of Managers' and Nonmanagers' Responses*, NASA Tech. Memo. 101625 (Hampton, VA: NASA Langley Research Center, August 1989), and *Technical Communication in Aeronautics: Results of an Exploratory Study—An Analysis of Profit Managers' and Nonprofit Managers' Responses*, NASA Tech. Memo. 101626 (Hampton, VA: NASA Langley Research Center, October 1989).

- U.S.-origin databases still dominate the information markets of the industrialized nations, but many (especially the EEC and Japan) have explicit strategies to develop their own domestic information industries.

Perhaps the single most important step the U.S. Government can take is to recognize the important role of STI in strengthening U.S. competitiveness. In the immediate post-World War II years, the commanding across-the-board lead in science and technology meant that we could directly control the creation and dissemination of STI and needed to pay scant attention to foreign STI. Now, U.S. science and technology are under competitive pressure in many areas, and the U.S. lead in STI is no longer secure. Other developed countries—such as Japan and the European Community—are targeting STI as a key element of a national strategy, and seem committed to aggressively develop their own STI capabilities.[36] The imperative for a reinvigorated U.S. STI strategy is strong. As summed up by Dr. Lewis M. Branscomb of the J.F. Kennedy School of Government at Harvard University:

Perhaps the single most important step the U.S. Government can take is to recognize the important role of STI in strengthening U.S. competitiveness.

> Most other industrial democracies take information policy very seriously as an element of science policy and of strategies for competitiveness. In the U.S., for reasons I have never fully understood, information policy is the stepchild of economic policy and has lost its place in science policy. We spend our efforts discussing what information to keep, sell, or give away. The better question is how to create it, acquire it, and use it.[37]

[36]See McClure and Hernon, op. cit., footnote 2.

[37]Statement of Lewis M. Branscomb, Director, Science, Technology, and Public Policy Program, J.F. Kennedy School of Government, Harvard University, before a hearing of the U.S. Senate Committee on the Judiciary, Subcommittee on Technology and the Law, Mar. 16, 1988. Dr. Branscomb formerly served as Chief Scientist of the IBM Corp., and as Director of the National Bureau of Standards.

Chapter 3

Reaching Consensus on Principles of Federal Scientific and Technical Information Dissemination

Many STI managers in the Federal agencies, along with scientists, engineers, scholars, librarians, and vendors who specialize in STI, recognize the highly leveraged role of Federal STI in renewing the U.S. competitive edge. However, during most of the 1980s, sharp debate over several key elements of Federal information policy and the resulting lack of consensus have prevented the STI community from sending a clear message to top congressional and executive branch policymakers. The most controversial aspects of STI policy have been:

- the Federal role in information dissemination;
- principles of STI dissemination;
- policy on the open flow of STI; and
- role of the governmentwide dissemination agencies.

In all these areas, electronic technologies aggravate old issues or create new ones.

During the last year and a half, the debate in Congress has advanced to the point where a greater degree of consensus and, thus, legislative action is possible. Unanimous consent may be unlikely on some issues, but if the potential of STI is to be realized, a working consensus is needed. This chapter discusses the debate over principles of STI dissemination, including the Federal role. Chapter 4 covers the policy debates on the open flow of STI, and on the role of the governmentwide dissemination agencies.

The ongoing information policy debates are directly relevant to efforts by the 101st Congress to update public laws on Federal information dissemination—including the Paperwork Reduction Act, Printing Act, Depository Library Act, and Freedom of Information Act.[1]

Federal Role in Information Dissemination

STI has been caught up in the philosophical debate over the role of the Federal Government in disseminating Federal information to the public. All sides of the debate agree on the need for some Federal role, but agreement on specifics, especially with respect to the relative roles of the government and private sector in dissemination, is more elusive. Federal STI is relevant to both the missions of the research and development agencies and to governmentwide dissemination objectives. In the absence of a governmentwide strategy or policy for STI dissemination, the development of a comprehensive information dissemination policy under the auspices of the Office of Management and Budget (OMB) is of greater importance.

OMB and Circular A-130

OMB is the dominant force in shaping Federal STI dissemination policy.[2] Its role was strengthened by the Paperwork Reduction Act of 1980,[3] which established an Office of Information and Regulatory Affairs (OIRA) within OMB. The Act was amended in 1986 to explicitly include information dissemination within its scope.[4] The Act assigns the OIRA Director broad responsibilities to minimize the cost and maximize the usefulness of information collected, maintained, and disseminated by the Federal Government. Further, the Act requires the OIRA Director to develop and implement Federal information policies, principles, standards, and guidelines with respect to information collection and dissemination. The Act also requires each Federal agency to

[1]For a detailed discussion of how technology has outpaced the law, see U.S. Congress, Office of Technology Assessment, *Informing the Nation: Federal Information Dissemination in an Electronic Age*, OTA-CIT-396 (Washington, DC: U.S. Government Printing Office, October 1988).

[2]See, for example, C.R. McClure and P. Hernon, *U.S. Scientific and Technical Information Policies: Views and Perspectives* (Norwood, NJ: Ablex Publishing Corp., 1989); C.R. McClure, P. Hernon, and H. Relyea (eds.), *United States Government Information Policies: Views and Perspectives* (Norwood, NJ: Ablex Publishing Corp., 1989); statement of Harold B. Shill, Associate Professor, West Virginia University, on behalf of the West Virginia Library Association and West Virginia University Libraries, before a May 23, 1989, hearing of the House Government Operations Subcommittee on Government Information, Justice, and Agriculture; statement of Harold B. Shill, on behalf of the American Library Association, Legislative Assembly, before a July 14, 1987, hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research and Technology.

[3]Public Law 96-511, Dec. 11, 1980.

[4]Public Law 99-500, Oct. 18, 1986, and Public Law 99-591, Oct. 30, 1986.

STI has been caught up in the philosophical debate over the role of the Federal Government in disseminating Federal information to the public.

designate a senior official to be responsible for agency compliance with OIRA policies, principles, standards, and guidelines on information collection and dissemination.[5]

While the authority of OIRA clearly extends to information dissemination, Congress did not—at least in the Paperwork Reduction Act—provide guidance on the shape, direction, or even basic philosophy of information dissemination policies that might be promulgated by OIRA. Part of the reason for this omission is that, at the time the Paperwork Reduction Act was being debated and enacted, other committees were considering legislation on the printing chapters of Title 44 of the U.S. Code (chs. 1-19; the PRA is ch. 35) that would have addressed key aspects of information dissemination.[6] This parallel legislation was not enacted. And Congress has not yet provided explicit statutory guidance to OIRA on information dissemination policy, although the 101st Congress is considering a variety of legislative proposals to amend various chapters of Title 44.[7]

OMB's efforts during the 1980s to promulgate governmentwide information dissemination policy proved to be controversial.[8] Much of the controversy focused on the role of the private sector in information dissemination and charges to be levied for use of Federal information dissemination. Both the draft and final versions of OMB Circular A-130 on "Management of Federal Information Resources" emphasized that Federal agencies place "maximum feasible reliance" on the private sector for information dissemination, and that costs be recovered through user charges where appropriate.[9]

The final December 1985 version of OMB Circular A-130 gave more explicit recognition to the importance of government information, but still emphasized the role of the private sector. Thus, Federal agency dissemination must be either "specifically required by law" or "[n]ecessary for the proper performance of agency functions," provided that the information products and services disseminated "do not duplicate similar products or services that are or would otherwise be provided by other government or private sector organizations."[10] In effect, in the absence of statutory guidance to the contrary, OMB applied the philosophy of OMB Circular A-76 regarding contracting out of commercially available services in general to information dissemination in particular.[11]

However, A-76 does not address or define what dissemination functions are "inherently" governmental, that is, are "so intimately related to the public interest so as to mandate performance by

[5]Public Law 96-511 as amended, sec. 3501, 3504, 3506.

[6]H.R. 5424, the "National Publications Act of 1980," 96th Cong., 2d sess., Sept. 27, 1980.

[7]See, for example, H.R. 3695, the "Paperwork Reduction and Federal Information Resources Management Act of 1989," 101st Cong., 1st sess., Nov. 17, 1989; S. 1742, the "Federal Information Resources Management Act of 1989," 101st Cong., 1st sess., Oct. 6, 1989; and H.R. 3849, the "Government Printing Office Improvement Act of 1990," 101st Cong., 2d sess., Jan. 23, 1990. For related discussion, see OTA comments on S. 1742 prepared for a Feb. 21-22, 1990, hearing of the Senate Committee on Governmental Affairs, and the statement of Fred B. Wood, OTA, on H.R. 3849 before a Mar. 7, 1990, hearing of the Committee on House Administration, Subcommittee on Procurement and Printing.

[8]See OTA, *Informing the Nation*, op. cit., footnote 1, ch. 11; H.C. Relyea, J. Bortnick, and R.C. Ehlke, *Management of Federal Information Resources: A General Critique of the March 1985 OMB Draft Circular* (Washington, DC: Congressional Research Service, Library of Congress, July 5, 1985); and P. Hernon and C.R. McClure, *Federal Information Policies in the 1980s: Conflicts and Issues* (Norwood, NJ: Ablex Publishing Corp., 1987). Also see "Librarians Fight Government Plan," *New York Times*, Feb. 21, 1989, p. A17; J. Markoff, "Giving Public U.S. Data: Private Purveyors Say No," *New York Times*, Mar. 4, 1989, pp. A1, 47; J. Markoff, "Policy Shift on Access to U.S. Data," *New York Times*, Apr. 10, 1989, pp. D1, D8; D. Sherwood, "Data Wars," *Government Executive*, April 1989, pp. 24 ff; C. Webb, "Government Databases: Competing With Private Services?" *Presstime*, April 1989, pp. 18-20; T.J. McIntosh, "Electronic Age Offers Promises, Problems for Government Information," *BNA Daily Report for Executives*, Aug. 11, 1989, pp. C-1 to C-17; and W.J. Moore, "Access Denied," *National Journal*, Jan. 20, 1990, pp. 121-124.

[9]Office of Management and Budget, draft, "Management of Federal Information Resources," *Federal Register*, vol. 50, No. 51, Mar. 15, 1985, pp. 10734-10747; Office of Management and Budget, Circular A-130, "Management of Federal Information Resources," vol. 50, Dec. 24, 1985, pp. 52730-52751.

[10]OMB Circular A-130, secs. 9(a) and (b).

[11]J. Timothy Sprehe, "Developing Federal Information Resources Management Policy: Issues and Impact for Information Managers," *Information Management Review*, vol. 2, No. 3, 1987, see pp. 33-41; and OMB Circulars A-76, Aug. 4, 1983, and A-130, Dec. 12, 1985.

Government employees.''[12] OTA's prior analysis of National Technical Information Service (NTIS) and Government Printing Office (GPO) privatization proposals suggested that many NTIS and GPO dissemination functions are not suitable for privatization. Many other agency information dissemination functions arguably are vital to agency performance of statutory missions. There have been few credible analyses of the factors that make contracting out of Federal information dissemination cost-effective. Such analyses are difficult.[13]

OMB Circular A-130 has been widely interpreted by agencies as strongly encouraging, if not requiring, user charges for information dissemination. However, a careful reading of A-130 indicates that pricing decisions, unless specifically prescribed by statute, are left up to the discretion of agency heads, who may set charges no greater than that required to recover the cost of dissemination and who may waive or eliminate charges if necessary to carry out mission objectives.

STI Agencies and Circular A-130

The net effect of Circular A-130 has been to polarize views on Federal information dissemination policy, divert significant time and resources into debate over what A-130 is or should be, and create uncertainty or risk aversion among Federal agencies with respect to dissemination. Federal science agencies were not immune from this policy environment. Some STI agencies, notably NTIS and various agency information clearinghouses and libraries, had to defend their programs against privatization proposals. In the case of NTIS, OMB's insistence on privatization—which was later overruled by Congress—might have resulted in a 2- or 3-year delay in its modernization. Some STI agencies have adopted a defensive, low-profile attitude toward information dissemination, as a way of coping with the A-130 environment.

OMB's privatization policy could have accelerated if A-130 went unchanged and Federal agencies issued their own departmental regulations to implement A-130. The Department of Commerce is a case in point: it is particularly important because several Commerce agencies have significant STI functions (e.g., NTIS, National Oceanic and Atmospheric Administration (NOAA), National Institute of Standards and Technology (NIST), and the Patent and Trademark Office (PTO)).

In August 1988, the Department of Commerce issued a draft policy on electronic information dissemination.[14] Commerce was the first and, as yet, only Federal agency to develop a proposed comprehensive policy. The draft was prepared by a departmental task force and was intended to carry out the requirements of the Paperwork Reduction Act and A-130. The draft policy was circulated for comment and revised several times, but was never published in the *Federal Register* and has since been put on indefinite hold, due to the change in administration and more recently to the subsequent changes in OMB policy direction. Nonetheless, it is useful to review the original Commerce draft policy as an example of what might emerge as agency implementation of A-130 if left unaltered.

The basic thrust of the draft Commerce policy was that ''[o]perating units will use private sector firms to develop, manage, and operate electronic dissemination activities to the maximum extent possible,'' and that, ''before initiating electronic information dissemination, operating units will conduct a privatization analysis.'' The proposed policy placed the burden of proof on the agency to ''justify any proposed direct Federal role in disseminating electronic information in terms of overriding public need, law, and/or program mission.'' The directive was particularly burdensome with respect to the development and dissemination of value-added electronic information products and services, and in the marketing and distribution of agency information, all functions which the Department felt should be carried out primarily by the private sector. The Department, in its own ''highlights'' sheet, noted that, as a standard of performance, Commerce's

[12] OMB Circular A-76.

[13] OTA, *Informing the Nation*, op. cit., footnote 1, ch. 12. Also see F.B. Wood, ''Proposals for Privatization of the National Technical Information Service: A Viewpoint,'' *Government Publications Review*, vol. 15, 1988, pp. 403-409.

[14] U.S. Department of Commerce, Draft Department Administrative Order on ''Electronic Information Dissemination,'' Aug. 5, 1988, published in part as ''Draft Policy of the U.S. Department of Commerce on the Dissemination of Information in Electronic Format,'' *Government Information Quarterly*, vol. 6, No. 1, 1989, pp. 89-96.

Federal information dissemination policy development appears to be moving toward a compromise on two of the most contentious issues: the roles of the government and the private sector; and the application of user charges.

electronic dissemination activities should "[o]ffer no value-added features." Likewise, the draft policy placed the burden of proof on the agency to justify why fees to recover the actual costs of dissemination should not be applied.

Overall, the proposed policy placed so many substantive and procedural hurdles in the path of agency electronic dissemination activities that innovation and creativity could have been seriously impaired. Even though the policy stipulated procedures by which agency components could have justified government electronic dissemination and/or fee waivers, the procedural burden was high enough to discourage agency initiatives.

An Emerging Consensus?

In *Informing the Nation*, OTA reviewed a large number of agency-specific and governmentwide statutes with regard to congressional intent on information dissemination. While the Paperwork Reduction Act itself provides little direct guidance, taking as a whole the body of public law, OTA concluded that congressional intent is clear:

> In general, unimpeded dissemination of and access to Federal information is encouraged or frequently required and is vital to performance of agency and programmatic missions established by statute as well as to the principles of open government and a democratic society.[15]

OTA suggested that Congress consider making a renewed commitment to the overriding principle of public access established by Congress in other statutes, but updated to reflect the increasingly electronic nature of Federal information. In particular, OTA suggested that Congress consider enacting a congressional version of the information dissemination principles addressed in OMB's Circular A-130.[16]

Since publication of *Informing the Nation*, a number of other key reports, OMB draft policies, and, recently, congressional testimony and bills have been issued.[17] Federal information dissemination policy development appears to be moving toward a compromise on two of the most contentious issues: the roles of the government and the private sector; and the application of user charges.

The shift in OMB thinking is illustrative. In January 1989, OMB issued an "Advance Notice of Further Policy" to revise A-130 that was interpreted as favoring private sector over government dissemination of Federal information, limiting agency dissemination to basic and not value-added electronic information products, and requiring user fees to recover the costs of dissemination, absent compel-

[15] OTA, *Informing the Nation*, op. cit., footnote 1, p. 259.

[16] Ibid., p. 260.

[17] See, for example, J.J. Berman, "The Right to Know: Public Access to Electronic Information," paper prepared for the Markle Foundation, in P.R. Newberg (ed.), *New Directions in Telecommunications Policy*, vol. 2, *Information Policy and Economic Policy* (Durham, NC: Duke University Press, 1989); statements of J.J. Berman, Director, Information Technologies Project, American Civil Liberties Union, before an Apr. 18, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, and a Feb. 22, 1990, hearing of the Senate Committee on Governmental Affairs; G. Bass and D. Plocher, *Strengthening Federal Information Policy: Opportunities and Realities at OMB*, Benton Foundation, Project on Communications and Information Policy Options (Washington, DC: The Benton Foundation, 1989); statement of David Plocher, Staff Attorney, OMB Watch, before a May 24, 1989, hearing of the House Committee on Administration, Subcommittee on Procurement and Printing; statements of Nancy Kranich, Director of Public and Administrative Services, New York University Libraries, on behalf of the American Library Association, and D. Kaye Gapen, Dean of Libraries, University of Wisconsin, on behalf of the Association of Research Libraries, before a May 23, 1989, hearing of the House Committee on Government Government Operations, Subcommittee on Government Information, Justice, and Agriculture; statements of Alan F. Westin, President, Reference Point Foundation, and Professor of Public Law and Government, Columbia University, and Kenneth B. Allen, Senior Vice President for Government Relations, Information Industry Association, before an Apr. 18, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture; H.H. Perritt, Jr., *Electronic Acquisition and Release of Federal Agency Information*, Report to the Administrative Conference of the United States, Oct. 1, 1988; statement of Henry H. Perritt before a July 11, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture; and Administrative Conference of the United States, Recommendation 88-10 on "Federal Agency Use of Computers in Acquiring and Releasing Information," adopted Dec. 8-9, 1988.

ling reasons to the contrary.[18] The public comment on the January OMB notice was overwhelmingly critical.[19] OMB concluded that the January draft did not accurately communicate OMB's policy views and had further confused and polarized the debate. As a consequence, on June 15, 1989, OMB issued a "Second Advance Notice of Further Policy Development on Dissemination of Information" that formally withdrew the January 4 notice, summarized the comments received, and presented OMB's reactions and preliminary conclusions.[20] On June 16, OIRA Administrator Jay Plager announced the withdrawal in testimony before the Subcommittee on Government Information and Regulation of the Senate Committee on Governmental Affairs.[21]

The June 15, 1989, OMB notice deserves careful scrutiny by the STI community, because OMB intends to prepare a new draft policy consistent with the discussion in the June 15 notice and with any relevant legislation that may be enacted. (The new draft will also incorporate information collection, based on a 1987 draft and comments received thereon.[22]) If history is any guide, the penultimate OMB policy can be expected to have a significant impact on Federal STI dissemination.

The essence and significance of the June OMB notice is captured in the following quotation:[23]

> OMB wishes to make clear that its fundamental philosophy is that government information is a public asset; that is, with the exception of national security matters and such other areas as may be prescribed by law, it is the obligation of the government to make such information readily available to the public on equal terms to all citizens; that to the extent the flow of information from the government to the public can be enhanced by the participation of the private sector, such participation should be encouraged; and that participation by the private sector supplements but does not replace the obligations of government. These principles apply whatever the form, printed, electronic, or other in which the information has been collected or stored. OMB did not intend that either OMB Circular A-130 or the January 1989 notice should have the effect of dissuading agencies from carrying out activities they believe are necessary for the proper performance of agency functions . . . or that Federal agencies or the public should be made to rely primarily on the private sector for the dissemination of government information.

Principles of STI Dissemination

Converging views on the Federal role in information dissemination has made legislative action possible. Various congressional committees are developing legislative proposals to provide OMB and Federal agencies with specific statutory guidance on information dissemination.[24] Legislation and related OMB policy can be expected to have a significant impact on Federal STI dissemination.

The STI community needs to monitor, carefully review, and participate in the development of these initiatives to ensure that governmentwide dissemination principles are consistent with those appropri-

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[18] Office of Management and Budget, "Advance Notice of Further Policy Development on Dissemination of Information," *Federal Register*, vol. 54, No. 2, Jan. 4, 1989, pp. 214-220.

[19] See summary of comments in Office of Management and Budget, "Second Advance Notice of Further Policy Development on Dissemination of Information." *Federal Register*, vol. 54, No. 114, June 15, 1989, pp. 25554-25559.

[20] Ibid.; also see J. Markoff, "O.M.B. Proposes Switch in Information Policy," *New York Times*, June 10, 1989, p. A-28; and U.S. Office of Management and Budget, "Summary of Comments on OMB's Second Advance Notice of Further Policy Development on Dissemination of Information," Oct. 19, 1989.

[21] Testimony of Jay Plager, Administrator, OMB Office of Information and Regulatory Affairs, before a June 16, 1989, hearing of the Senate Committee on Governmental Affairs, Subcommittee on Government Information and Regulation. Also see testimony of Jay Plager before a June 28, 1989, hearing of the House Committee on Administration, Subcommittee on Procurement and Printing; see U.S. Congress, House, Committee on House Administration, Subcommittee on Procurement and Printing, *Title 44 U.S.C.—Review*, Hearings, May 23, 24 and June 28, 29, 1989, 101st Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, 1989), pp. 152-159.

[22] See Office of Management and Budget, "Policy Guidance on Electronic Collection of Information," *Federal Register*, vol. 52, No. 152, Aug. 7, 1987, pp. 29454-29457; and OMB, "Summary of Comments on Policy Guidance on Collection of Information," Nov. 17, 1987.

[23] OMB, "Second Advance Notice," op. cit., footnote 19, p. 25557.

[24] See H.R. 3695 and S. 1742, op. cit., footnote 7.

ate for STI, and, if not, to make sure that separate guidance is provided for STI.[25]

Strengthening Public Dissemination of Value-Added Federal STI

Most agree on the need for public dissemination of STI, but there are differences on how this should be achieved. One serious complication for STI occurs when unclassified information is deemed to be sensitive for reasons of national security, foreign policy, or competitiveness. In these cases, the goal of public access may conflict with other policy objectives. Policy on the open flow of STI is treated as a separate issue area and discussed in chapter 4. The Federal science agencies emphasize that the primary purpose of Federal STI is to support agency R&D missions, and that public dissemination is an important but secondary objective.

A further complication occurs when value-added Federal STI is involved. Some government and information industry officials have argued that Federal agency electronic dissemination of raw data was acceptable, but government dissemination of value-added information was not an appropriate governmental function and should be the province of private industry.[26] In this view, dissemination by the U.S. Geological Survey of STI on magnetic computer tape would have been appropriate, but USGS dissemination of value-added or enhanced information would not—e.g., a compact optical disk with data on earthquake monitoring that also included the search software for retrieving and manipulating the data.

Value-added is not the best determinant to distinguish between government and private-sector roles. Many Federal science (and other) agencies have legislative responsibilities to develop and disseminate value-added information, and have been doing so for decades. Restricting the Federal agencies from providing value-added information, or from providing information available on paper in electronic form, would prevent some Federal agencies from meeting statutory obligations. Value-added restrictions could prevent agencies from providing the benefits of electronic technologies through automated data services to taxpayers who collectively paid for the development of the information in the first place.

Federal agencies should be able to provide value-added information that furthers agency missions, but they should carefully consider private-sector capabilities, so that contracting out and marketplace alternatives are utilized when appropriate. Private information vendors (commercial and not-for-profit), on the other hand, should be encouraged to repackage and resell Federal information (that is not classified or otherwise restricted), and to add further value to create enhanced information products and services where the market exists. Whether government or private dissemination is preferred, however, should not be based on ideology, but on which mode(s) can best serve national needs.

Improving Cost-Effectiveness and Diversity of Federal STI

OMB has long supported agency automation programs in the belief that automation will be cost-effective in the long term. The judicious use of electronic technologies could lead to more timely, complete, and accurate Federal information dissemi-

[25]For historical perspective on the development of information dissemination principles, see, for example, U.S. Executive Office of the President, Domestic Council, *National Information Policy*, report to the President of the United States (Washington, DC: National Commission on Libraries and Information Science, 1976); J.H. Yurow, R.F. Aldrich, R.R. Belair, Y.M. Braunstein, D.Y. Peyton, S. Pogrow, L.S. Robertson, and A.B. Wildavsky, *Issues in Information Policy*, report prepared for the National Telecommunications and Information Administration, U.S. Department of Commerce, NTIA-SP-80-9 (Washington, DC: U.S. Government Printing Office, February 1981); U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information and Individual Rights, *Government Provision of Information Services in Competition With the Private Sector*, Hearing, 97th Cong., 2d sess. (Washington, DC: U.S. Government Printing Office, Feb. 25, 1982); Rep. Glenn English, "Electronic Filing of Documents With the Government: New Technology Presents New Problems," *Congressional Record-House*, Mar. 14, 1984, H1614-1615; U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, *Electronic Collection and Dissemination of Information by Federal Agencies*, Hearings, Apr. 29, June 26, and Oct. 18, 99th Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, 1986); U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, *Electronic Collection and Dissemination of Information by Federal Agencies: A Policy Overview*, House Report 99-560, 99th Congress, 2d sess. (Washington, DC: U.S. Government Printing Office, Apr. 29, 1986); U.S. Congress, House, H.R. 2600, *Securities and Exchange Commission Authorization Act of 1987*, 100th Cong., 1st sess., June 4, 1987; U.S. Congress, House, Committee on Energy and Commerce, *Securities and Exchange Commission Authorization Act*, report to accompany H.R. 2600, 100th Cong., 1st sess., Rep. No. 100-296 (Washington, DC: U.S. Government Printing Office, Sept. 9, 1987); and U.S. Congress, House, Committee on Government Operations, *Federal Information Dissemination Policies and Practices*, Hearings, Apr. 18, May 23, and July 11, 1989, 101st Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, 1989).

[26]This view was reflected in the U.S. Department of Commerce, Draft Administrative Order on "Electronic Information Dissemination," Aug. 5, 1988, and the Office of Management and Budget "Advance Notice of Further Policy Development on Dissemination of Information," Jan. 4, 1989.

Federal agencies should be able to provide value-added information that furthers agency missions, but they should carefully consider private-sector capabilities, so that contracting out and marketplace alternatives are utilized when appropriate.

nation. However, the 1980s offer several examples of agency electronic dissemination projects that went astray or suffered serious and sometimes costly problems. In part, this is the price of innovation and progress—and neither is private sector R&D immune from "wrong tracks," "blind alleys," and "learning the hard way." Nonetheless, this points up the need for better ways for Federal agencies to share learning among themselves and the private sector. The most cost-effective route may sometimes be primarily an agency initiative, at other times defer entirely to the private sector, or develop collaboratively by the agency and a private firm. There is room for more creative approaches in optimizing Federal investment in information dissemination. While cost-effectiveness is an important criterion, it must be balanced with the principal goals of fulfilling the statutory R&D requirements of the science agencies and promoting public dissemination of STI.

It is important to maintain and broaden the avenues used for dissemination of Federal information, including STI. For STI, these avenues are:

- the Federal science agencies themselves;
- the governmentwide dissemination agencies such as NTIS and GPO;
- the press (including print and electronic media and a wide range of specialized scientific and technical journals and newsletters);
- commercial information vendors (ranging from small companies that specialize in a few areas of STI, to very large corporations with entire divisions devoted to STI publishing, databases, etc.);
- not-for-profit information vendors (including university and foundation-based providers);
- researchers and scholars who collect, analyze, and synthesize Federal STI and disseminate the results through multiple channels (ranging from conference presentations, to congressional testimony, to technical reports);
- professional, consumer, and trade associations that specialize in areas relevant to STI (and process and redisseminate STI to their own constituencies);
- the library community (including public, private, special, academic, research, and school libraries throughout the Nation);
- State and local governments and associations; and
- foreign countries and companies that use Federal STI for policy or commercial purposes.

Involving Users and Providers in STI Planning

Planning for Federal information (including STI) dissemination should provide opportunities for the users and the public to participate in the process, as well as the appropriate agencies. Inadequate involvement of the potential users has led to past failures in new information services. User involvement is especially important for STI, because user groups are often highly specialized and sophisticated.[27]

Some agency officials are concerned that public participation in STI planning could become cumbersome and slow down or discourage agency innovation. On one hand, the use of public funds for information systems to carry out public purposes suggests the need for an open process. On the other hand, procedural red tape could chill agency innovation, as it sometimes has in the private sector. The key is to match the procedural requirements to the purpose, nature, and scale of the project. For example, multi-million dollar systems like the National Aeronautics and Space Administration's EOS (Earth Observing System) or the Securities and Exchange Commission's EDGAR (Electronic Data Gathering and Retrieval) may be required to follow rigorous public notice and participation procedures. At the other extreme, small pilot or demonstration projects may be required to include public notice but not to use a formal comment period, meetings, and approval procedures that may be needed for large operational projects.

[27] See statements of Charles R. McClure, Syracuse University; Fred B. Wood, OTA; and Joseph G. Coyne, U.S. Department of Energy before a hearing of the House Committee on Science, Space, and Technology, Subcommitee on Science, Research, and Technology, Oct. 12, 1989.

Most user and provider groups support the alternative concept of marginal cost recovery—meaning that user charges for Federal information dissemination would not exceed the marginal cost of dissemination and would not include costs of collecting or creating the information.

Determining User Charges for Federal STI

User charges continue to be controversial. Some at OMB have advocated full cost recovery for Federal information dissemination. Under this policy, user charges for Federal information could have been set to recover the entire costs of collecting, processing, and maintaining as well as disseminating. This proposal was opposed by both user and provider groups, on the grounds that much Federal information—including STI—would be priced out of reach, and that the taxpayer would effectively be asked to pay twice.[28]

Experience with Landsat STI suggests that the academic research community is particularly burdened by full cost pricing. Responsibility for pricing of Landsat imagery and digital data has moved in the past from the U.S. Geological Survey (USGS) to the National Oceanic and Atmospheric Administration and finally to EOSAT, a commercial company established under the Land Remote-Sensing Commercialization Act of 1984.[29]

During the 1980s, Landsat STI prices have been increased to recover a greater portion of full costs to the point where 1989 EOSAT prices are about nine times higher than 1980 prices for imagery and three times higher for digital data.[30] This has reduced sales to academia by more than half.[31]

Transition from manual imagery interpretation to digital data analysis explains part of the reduction in imagery sales, but examination of worldwide Landsat sales for 1981-88 shows that users are paying much more for much less. For example, between 1981 and 1988, the volume of data digital sales increased by only 10 percent while the revenue from digital data sales increased by about 600 percent. During this same period, the volume of imagery sales decreased by about six times, while the corresponding revenues increased by 10 percent.[32] Full cost prices are affordable by some large government agencies and private corporations (U.S. and foreign), but these prices have squeezed research activities performed by academia, State/local governments, small business, individuals, and some Federal agency programs that are faced with tight budgets (including, ironically, some USGS programs).[33]

Most user and provider groups support the alternative concept of marginal cost recovery—meaning that user charges for Federal information dissemination would not exceed the marginal cost of dissemination and would not include costs of collecting or creating the information. The definition of "marginal cost" is ambiguous. Three definitions have been suggested:

1. Marginal cost is the incremental cost of producing the n+1 unit of a specific information product or service. Thus, the cost per copy of a printed report would be the direct cost of producing one more paper copy; the cost of a database would be the direct cost of one more

[28]Full cost recovery has also been opposed on legal grounds. The courts have ruled that, under the User Fee Act of 1952 (31 U.S.C. 9701), user fees charged by Federal agencies must be reasonably related to the direct and indirect costs of providing a product or service. For relevant decisions, see 846 F.2d 765 (D.C. Cir. 1988); 777 F.2d 722 (D.C. Cir. 1985); 554 F.2d 1109 (D.C. Cir. 1976); and 554 F.2d 1094 (D.C. Cir. 1976).

[29]U.S. Congress, Public Law 98-365, July 17, 1984. For general discussion of Landsat commercialization, see U.S. Congress, Office of Technology Assessment, *Remote Sensing and the Private Sector: Issues for Discussion*, OTA-TM-ISC-20 (Washington, DC: U.S. Government Printing Office, March 1984); U.S. National Commission on Libraries and Information Science, *Information Policy Implications of Archiving Satellite Data: To Preserve the Sense of Earth From Space* (Washington, DC: 1984); and National Research Council, Space Applications Board, *Remote Sensing of the Earth From Space: A Program in Crisis* (Washington, DC: National Academy Press, 1985).

[30]G. Metz, "Landsat Product Price Examples, 1980-1989," EROS Data Center, Sioux Falls, ND.

[31]The percent of total EROS sales to academia declined from 10% in FY1979 to 5% in FY1988 for Landsat imagery, and from 14% in FY1979 to 5% in FY1988 for Landsat data. In FY1988, only 408 frames of imagery and 379 data items were sold to academic users.

[32]G. Austin, R. Pohl, and G. Metz, *A Summary of Worldwide Landsat Sales: 1988* (Sioux Falls, SD: EROS Data Center, U.S. Geological Survey, May 30, 1989).

[33]Also see G. Austin, *Annual Report of Landsat Sales for Fiscal Year 1988* (Sioux Falls, SD: EROS Data Center, U.S. Geological Survey, 1989).

electronic copy (e.g., on magnetic tape) or one more hour of online access time.

2. Marginal cost is the average cost of producing a specific product or service. Here, the cost per copy of a printed report would be the total costs of producing n copies divided by the number of copies. The cost of a database would be the total costs of providing the database divided by the number of service units (e.g., magnetic tape copies, hours of access time).
3. Marginal cost is the average cost of a group of products or services (i.e., a product line). Thus, the cost per copy of a printed report would be the total costs of producing $n_1+n_2+n_x$ copies of $m_1+m_2+m_y$ reports divided by the total number of copies. The cost of a database would be the total costs of providing n databases divided by the total number of service units for all databases combined.

Definition 1 is the true economic marginal cost. But if the intent is to recover the cost of dissemination but not the costs of collecting or creating the information, then definitions 2 and 3 could apply. True marginal pricing reflects only direct variable costs (e.g., labor and materials used in printing), whereas average costs typically also cover direct fixed costs (e.g., production line supervision, electricity) and some share of indirect costs (e.g., building rent, marketing, general management, capital investment).

A major policy question is whether the price formula should apply to an individual information product or service or to a line of products and services; what costs elements should be included (variable, fixed, direct, indirect); and how much flexibility agencies should have in pricing. The demand for Federal information varies widely, and per-unit costs for the high sales volume items will be relatively low, while per-unit costs for the low-volume items will be relatively high.

For example, the user charge for a compact optical disk could vary from $5 to $500 depending on the pricing formula and volume of demand. At a sales volume of 500 copies, the true marginal cost (definition 1) would be about $5 per copy and the average cost (definition 2) typically $50 to $100 per copy. At a sales volume of 50 copies, the marginal cost might increase to $10 to $20 per copy and the average cost to $500 per copy. Thus true marginal cost yields the lowest price, but leaves much of the cost of dissemination uncovered. The uncovered costs would have to be paid from appropriated funds. The average cost formula covers the cost of dissemination, but is very sensitive to total volume. For high-volume items, average cost is low and vice versa.

As an illustration, NOAA appears to use definition 2 above, the average cost of producing a specific product or service, as the basis for pricing. NOAA includes both direct and indirect costs in its calculations. Typical direct costs are labor, supplies, printing, and computer resources. Indirect costs cover a portion of NOAA and U.S. Department of Commerce overhead and rent. The costs of collecting or creating the data are not included. NOAA calculates the total direct and indirect cost of producing each product or service, and divides the total cost by the quantity produced to determine a per-unit cost. Assuming that estimated demand meets or exceeds the quantity produced, the unit price is usually set to equal the unit cost.

The cost breakdown for several NOAA National Geophysical Data Center CD-ROM products is shown in table 1. The Geophysics of North America CD-ROM was relatively expensive to produce, but the unit cost was kept down due to the higher estimated sales volume and quantity produced. The Gloria CD-ROM was a pilot project subsidized by USGS—thus the low price. And the Deep Sea Drilling CD-ROM was inexpensive to produce, with a low unit price even with modest estimated demand.

Many STI items have low total sales, and thus the price could be prohibitive if calculated on an average-cost-per-product basis (definition 2). Low-demand STI items might be best suited for either true marginal cost pricing (with the rest of the costs covered out of appropriated funds) or average-cost-per-product-line pricing (definition 3). Both the National Technical Information Service (NTIS) and National Library of Medicine (NLM) use product-line pricing, which in effect results in a cross-subsidy between the high-demand and low-demand items. NTIS and NLM believe that use of true marginal cost pricing (definition 1) would threaten their viability, unless appropriated funds were provided to cover the rest of the costs; and that use of average cost pricing per product (definition 2) would further curtail demand for many of the lower volume information products and services, since prices for

Table 1—Cost Breakdown for Illustrative National Geophysical Data Center CD-ROM Products

Product	Cost elements: Direct labor	Other direct	Indirect costs	Quantity	Unit cost
Geophysics of North America: CD-ROM	$66K	$58K	$40K	700	$235
Documentation	23K	8K	14K	700	65
Software	53K	44K	32K	700	185
Gloria Side Scan Sonar: CD-ROM	6K[a]	—[a]	3K[a]	200	45
Deep Sea Drilling Project CD-ROM	6K	9K	3K	200	90

[a]USGS paid for the development of this pilot CD-ROM project.

SOURCE: National Geophysical Data Center, 1989.

these items would likely rise out of reach of many users.

NTIS must operate its clearinghouse on a break-even basis with no appropriated funds. NTIS uses revenues from brokerage fees and services to other agencies, along with product-line pricing, to help offset the losses that would otherwise occur due to the many NTIS documents that register no or very low sales volume. The sale or lease of Federal STI in electronic formats is now the fastest growing market segment for NTIS, increasing at 5 to 10 percent annually. "Electronic" sales account for about one-quarter of total NTIS revenues.[34]

NTIS sales of paper or microfiche documents continue to decline, with annual sales of indices, newsletters, published searches, and technical documents reaching all-time lows in fiscal year 1989. The average total demand for NTIS documents is about 10 copies over the life of a document, and one-quarter to one-third of the documents never sell a copy.[35]

Financing the NLM dissemination program is more complicated since (unlike NTIS) NLM does receive appropriated funds for creation of databases. This means that NLM must determine where tax-supported information collection or creation ends and user-financed information dissemination begins. According to NLM, online database prices are set to recover only the cost of dissemination (except for foreign users, who pay full cost since they presumably have not paid taxes). NLM uses average cost product-line pricing, which means that users pay the same average price for all databases ($27/hour during peak periods). The most heavily used database (MEDLINE) absorbs much of the overhead costs and helps keep prices down for the other databases (e.g., TOXLINE, AIDSLINE, CANCERLIT).[36] However, vendors are concerned that NLM combines both offline products (e.g., magnetic tapes) and online services when estimating costs, and cross-subsidizes not only from MEDLINE to other databases, but from offline products to online services through the use of royalty fees.

The NLM example raises several pricing questions. How should agencies distinguish among collection, creation, maintenance, and dissemination costs? What costs should be included in determining average or marginal cost? What products and/or services should be included in determining costs? Under what circumstances should products and services be kept separate or combined, for pricing purposes? Should agencies cross-subsidize different products and services, and if so, to what degree? How should product lines be defined, when calculating average costs over a range of products and/or

[34]FY 1989 NTIS sales of software and data sets from the NTIS inventory were $2.59 million, leasing of NTIS and other agency databases $2.35 million, and brokerage of other agency electronic items $1.41 million for a combined "electronic" sales of $6.35 million—about one-fourth of the $24.4 million total revenues.

[35]For further discussion, see OTA, *Informing the Nation*, op. cit., footnote 1, chs. 5 and 12; and testimony of Fred B. Wood of OTA before a Feb. 24, 1988, hearing on NTIS privatization and a Mar. 8, 1990, hearing on NTIS modernization held by the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology.

[36]Chairman, Board of Regents, National Library of Medicine, memorandum to the Assistant Secretary for Health, U.S. Department of Health and Human Services, "Response to Systems Review Board Recommendations on the Pricing of NLM Products and Services," May 29, 1984; and K.A. Smith, "Government Databases: The NLM Philosophy," *Database*, vol. 11, No. 3, 1988, p. 58.

services? How should agencies set prices for dissemination to special user groups such as foreign users who do not pay taxes or not-for-profit users who cannot afford even the average cost? Should agencies be able to retain sales revenues to help offset dissemination costs? (NLM retains about one-half or $6 million/year in an NTIS deposit account, and returns the rest to the U.S. Treasury.)

Whatever one's views on pricing formulae, there is a general consensus that user charges should not exceed the cost of dissemination, and that agencies should be able to reduce or waive user charges if needed to carry out agency missions. Should this pricing philosophy become governmentwide policy, reconciliation of other statutes might be necessary. For example, Title 44 of the U.S. Code requires that the Superintendent of Documents (SupDocs) set prices for government publications at cost plus 50 percent.[37] However, as a practical matter, in recent years the House and Senate Appropriations Committees have transferred net revenues from the SupDocs sales program to support the Depository Library Program (and thereby correspondingly reduce the need for DLP appropriated funds). Also, in 1988, Congress authorized the National Oceanic and Atmospheric Administration to assess fees based on "fair market value" for commercial users of certain NOAA information products and services (governmental, university, and not-for-profit users would pay only marginal costs).[38] NOAA officials have found it difficult to determine fair market value, and both agency and industry officials question whether this is a viable basis for setting user charges.

Defining Intellectual Property Rights in Federal STI

STI developed by or for the Federal Government, like other types of Federal information, by law may not be copyrighted. Some researchers and vendors include Federal information in scholarly works or commercial products that are copyrighted (e.g., a vendor who copyrights a new compact optical disk that includes bibliographic STI from multiple sources, one of which is the Federal Government).

The major issue concerns the use of so-called "copyright-like" devices by Federal agencies. Several science agencies use licensing agreements in their dissemination programs. NLM makes its online database MEDLINE available to both online and compact optical disk vendors, through a licensing agreement that levies charges estimated to equal the average per-unit cost for a user of the NLM line of databases.

NTIS similarly licenses its bibliographic database to private vendors through a licensing agreement and also serves as licensing agent for other agencies' databases.

The National Agricultural Library (NAL) distributes its AGRICOLA bibliographic database to vendors via NTIS. NTIS charges vendors $2,000/year for the yearly AGRICOLA data on magnetic tape, and $200/year for back files. NTIS retains all of this revenue. NTIS also charges online vendors $6 per AGRICOLA connect hour and $0.05/"hit" (a bibliographic citation on the desired subject), and CD-ROM vendors a fee equal to 25 percent of the disk sales price. These online and CD-ROM user fees are split 20 percent to NTIS and 80 percent to NAL.[39]

Some private vendors view such licensing arrangements as restrictive and illegal.[40] These vendors believe that agency licensing agreements discourage competition among commercial services and/or inhibit demand, and have the effect of restricting access to Federal STI. Other vendors find licensing agreements acceptable so long as they are nonexclusive and fairly priced. The NLM and NTIS licensing agreements appear to be nondiscriminatory in that any vendor can be licensed, and the fees are set to recover the cost of databases and related

[37] 44 U.S.C. 1708.

[38] S. 2209, Title IV, sec. 409.

[39] Gary K. McCone, National Agricultural Library, U.S. Department of Agriculture, letter to Fred B. Wood, Office of Technology Assessment, U.S. Congress, Dec. 28, 1989.

[40] For discussion of concerns about the NLM MEDLINE database, see U.S. Congress, House, Committee on Government Operations, *Electronic Collection and Dissemination*, Oct. 18, 1985, Hearings, and Apr. 29, 1986, Report, op. cit., footnote 25; and statement of P. James Terragno, President, Maxwell Online, Inc. before a July 11, 1989, hearing of the House Committee on Government Operations, Subcommitee on Government Information, Justice, and Agriculture. For the NLM view, see NLM, "Comments on the Twenty-Eighth Report by the Committee on Government Operations," June 5, 1986; and "NLM Policy on Database Pricing," December 1989.

operations.[41] Nonetheless, some vendors question whether the online connect hour charges accurately reflect identifiable government costs that vary as a function of the level of use or number of subscribers.

Some users and vendors believe that it would be better for agencies to provide information free of charge or charge only the true marginal cost. This, according to these vendors, would reduce or eliminate cost as a barrier to access, and presumably eliminate concerns about fees in licensing agreements. NASA's National Space Science Data Center (NSSDC) operates largely without fees. NSSDC disseminates computer tapes at no charge (if the tapes are returned after copying) and allows limited access to online databases, also at no charge, for scientific or educational use by:

- NASA installations;
- NASA contractors and grantees;
- other Federal agencies, contractors, or grantees;
- colleges and universities;
- State or local governments; and
- not-for-profit organizations.

NSSDC charges other users the marginal cost of $45 per magnetic computer tape (or $25 if the user supplies the tape) and direct processing costs for larger amounts of online database use. Online users pay their telecommunication charges, whether access is direct or over networks. NSSDC does not yet have a policy for high-density storage media such as CD-ROM.

NAL's AGRICOLA currently recovers about $60,000 per year of online revenues. At NLM, NTIS, and other agency data centers (e.g., NOAA's NGDC), revenues based on average cost pricing (and licensing agreements) comprise a much larger part of their operating budgets. The impact of changes in pricing policy would vary widely among agencies. Detailed financial analyses would be required to estimate revenue shortfalls—and the necessary compensating appropriation increases—under various pricing and licensing scenarios. And even if price was not an issue, some kind of agreements could be needed to maintain quality control and protect the integrity of agency databases. An agency has a valid interest in assuring that quality standards are met, a stated purpose of NLM's licensing agreements (along with cost recovery).

The de facto copyright of Federal information through the transfer of patent rights or rights in technical data from the Federal Government to contractors, employees, or private parties (e.g., companies, universities) presents another problem. Both Congress and the President have encouraged closer collaboration between the government and private sector to facilitate the commercialization of technology developed by or for the Federal Government. The transfer of patent rights and rights in technical data can encourage technology transfer, but both might restrict access to Federal information. High-tech companies and universities benefit from this policy, but the information industry, librarians, and the general public are concerned that access to Federal STI could be impaired if the policy is carried too far (see ch. 4 discussion).

Enhancing the Role of the Private Sector

The Federal Government can encourage the private sector in several ways: First, the government should ensure open and equitable access for those who seek Federal information regardless of cost. Second, the government is expected to assist the library and educational institutions distribute Federal information through technology-enhanced dissemination. This will require rethinking the future roles of libraries and schools in the information age, including new arrangements with the government and commercial sectors.[42]

Third, the commercial information industry expects the government to provide equitable, competitive conditions for contractors and vendors involved in Federal information dissemination. The Securities and Exchange Commission and Patent and Trademark Office have proposed "exchange agreements" whereby private contractors would provide the agencies with "free" automation services in return for exclusive rights for redissemination of agency information. These agreements were bitterly contested by Congress and the information industry as anticompetitive and have since been modified or

[41] For a recent debate, see R.C. Atkinson, "A Question of Information Policy," editorial, *Science*, vol. 246, Nov. 10, 1989, p. 733; and D.A.B. Lindberg, "Information Policy," letter to the editor, *Science*, vol. 246, Dec. 22, 1989, pp. 1547-1548.

[42] See OTA, *Informing the Nation*, op. cit., footnote 1, chs. 6 and 7; Association of Research Libraries, *Technology and U.S. Government Information Policies: Catalysts for New Partnerships* (Washington, DC: October 1987); U.S. Congress, Office of Technology Assessment, *Linking for Learning: A New Course in Education*, OTA-SET-430 (Washington, DC: U.S. Government Printing Office, November 1989); and U.S. Department of Education, Office of Library Programs, *Rethinking the Library in the Information Age* (Washington, DC: U.S. Government Printing Office, October 1988).

Increased availability of Federal STI in electronic formats should stimulate and strengthen the private-sector role in STI dissemination.

terminated. The industry insists that, when contractors disseminate Federal information, the agencies should be obligated to provide the same information on equal terms to any interested vendors.

The information industry is also sensitive to the prospect of direct competition between Federal agencies and commercial vendors. The industry now recognizes the legitimacy of direct government dissemination. The views of the Information Industry Association have changed from opposition to any direct electronic dissemination by government, to opposing agency dissemination of value-added but not basic or raw government information. The industry now supports a partnership or complementary relationship between government and industry. For example, improvements in agency dissemination of STI could stimulate new opportunities for private sector development of innovative STI products and services that cut across agency and disciplinary lines.

Some vendors now offer a variety of bulk rate, off-peak, and discount products and services to governmental and not-for-profit customers. The industry opposes any copyright-like restrictions on Federal agency information, and prefers that licensing or other agreements be offered on a nondiscriminatory basis to all competitors. The industry benefits from obtaining Federal information in electronic forms, since the cost of converting electronic information to commercial applications is typically less than working from paper formats. It follows that if the benefits of electronic formats are available to the commercial sector, they should also be available to the not-for-profit sector (e.g., libraries, universities, and noncommercial companies such as OCLC, Inc. and Reference Point, Inc.[43]).

Increased availability of Federal STI in electronic formats should stimulate and strengthen the private-sector role in STI dissemination. This has been shown to be true with online and compact optical disk formats. Collection and creation of the Federal STI databases and documents are paid for by the taxpayers. The development cost of many of these databases is beyond what most private organizations could afford or would risk on such a venture. These databases are a shared national resource. New electronic technologies enable the Federal science agencies to prepare and maintain these databases and distribute them to the public—including the private sector. Private vendors are thus assisted by the government in their business of redisseminating, repackaging, and enhancing Federal STI and converting it into marketable products and services.

Electronic Federal STI should also benefit commercial telecommunication companies.[44] As electronic Federal STI is accepted by users and demand for online services increases, the use of telecommunication gateway services should likewise increase. Market stimulation should extend to the Bell operating companies, long distance telephone carriers, commercial value-added networks, and also not-for-profit networks. The latter include the Online Computer Library Center network, Research Libraries Information Network, Western Library Network, and scientific networks such as Bitnet and NSFnet (operated by Educom and the National Science Foundation, respectively).

[43]Reference Point has recently initiated a project to develop a global environmental information network for the exchange of information on climate change, deforestation, loss of biodiversity, and other global environmental challenges.

[44]For general discussion of the U.S. communications infrastructure, see U.S. Congress, Office of Technology Assessment, *Critical Connections: Communication for the Future*, OTA-CIT-407 (Washington, DC: U.S. Government Printing Office, January 1990).

Chapter 4

Reaching Consensus on the Open Flow and Governmentwide Dissemination of Federal STI

Open Flow of STI

The U.S. scientific and technical enterprise is premised on the open exchange of STI. The basic premise of openness has generally been modified only in narrowly defined areas of STI relating to national security. Recently several trends have converged to raise questions about the need to restrict the flow of Federal STI for other reasons.

First, the United States is no longer a leader in many areas of science and technology. The U.S. advantage that existed during the post-World War II years, through the 1950s and 1960s, has evaporated. Second, the global economy is more competitive, with foreign countries and companies challenging U.S. dominance in several economic sectors. Third, the U.S. military industrial advantage is under competitive pressure from foreign manufacturers. Fourth, electronic technologies vastly speed up the collection, storage, dissemination, and use of STI and thus accelerate the rate of information transfer within the global scientific and technical community.

Several efforts to restrict access to Federal STI for economic or security reasons emerged in the 1980s.[1] The Department of Defense (DoD) generally supports an open exchange of basic research information to promote scientific progress in defense technology. However, some DoD agencies and services (e.g., especially the Air Force and National Security Agency (NSA)) favor restrictions on access to applied research and technical information. This led to proposals to give NSA the lead in ensuring government computer security and to extend NSA's authority to so-called "sensitive but unclassified" Federal information.[2]

"Sensitive but unclassified" was to include unclassified information that becomes sensitive to the national security when, for example, it is aggregated in electronic form and available over online databases. Opposition to this proposal by the commercial information industry, academia, scientific and library associations, civil liberties groups, and Congress led to enactment of the Computer Security Act of 1987. This act assigned the National Bureau of Standards (now the National Institute of Standards and Technology (NIST))—rather than NSA—the lead role for civilian computer security, and limited the role of DoD with regard to unclassified, civilian Federal information. Information industry and civil liberties representatives, among others, are still concerned about the NSA role in civilian information systems, and its potential to interfere with the free flow of unclassified Federal information.[3]

Congress seeks to ensure that the flow of scientific and technological information is equitable and

[1]See U.S. Congress, Office of Technology Assessment, *Federal Government Information Technology: Management, Security, and Congressional Oversight*, OTA-CIT-297 (Washington, DC: U.S. Government Printing Office, February 1986); *Commercial Newsgathering From Space*, OTA-TM-ISC-40 (Washington, DC: U.S. Government Printing Office, May 1987); *Marine Minerals: Exploring Our New Frontier*, OTA-O-342 (Washington, DC: U.S. Government Printing Office, July 1987), esp. ch. 7 on "Federal Programs for Collecting and Managing Oceanographic Data;" *The Regulatory Environment of Science*, OTA-TM-SET-34 (Washington, DC: U.S. Government Printing Office, February 1986); *International Competition in Services*, OTA-ITE-328 (Washington, DC: U.S. Government Printing Office, July 1987); *Defending Secrets, Sharing Data*, OTA-CIT-310 (Washington, DC: U.S. Government Printing Office, October 1987); *Science, Technology, and the First Amendment*, OTA-CIT-369 (Washington, DC: U.S. Government Printing Office, January 1988); *Holding the Edge: Maintaining the Defense Technology Base*, OTA-ISC-420 (Washington, DC: U.S. Government Printing Office, April 1989).

[2]U.S. Congress, Office of Technology Assessment, *Defending Secrets*, op. cit., footnote 1, chs. 1, 6, and 7; also see W.R. Blados, "Controlling Unclassified Scientific and Technical Information," *Information Management Review*, vol. 2, No. 4, 1987, pp. 46-60.

[3]Public Law 100-235, the "Computer Security Act of 1987," Jan. 8, 1988. Also see testimony of Kenneth Allen, Senior Vice President, Information Industry Association, and Marc Rotenberg, Director, Washington Office, Computer Professionals for Social Responsibility, before a May 4, 1989, hearing of the House Committee on Government Operations, Subcommittee on Legislation and National Security. The House Committee on Government Operations and industry and public-sector representatives are still not satisfied with the working relationship between NIST and NSA, and seek further assurances that NIST—not NSA—will be in charge of civilian computer security.

Too much emphasis on short-term commercialization of technology and related technical data could actually impair the U.S. long-term competitive posture.

reciprocal among nations.[4] The Secretary of State is directed to consider several factors in negotiating international scientific agreements:[5]

- scientific merit;
- equity of access by U.S. public and private entities to public (and publicly supported private) research and development (R&D) opportunities and facilities in each country which is a major trading partner of the United States;
- possible commercial or trade linkages with the United States which may flow from the agreement or activity;
- national security concerns; and
- any other factors deemed appropriate.

The "Stevenson-Wydler Technology Innovation Act of 1980"[6] and the "Federal Technology Transfer Act of 1986"[7] are efforts to reinforce the U.S. position in international competition by facilitating the transfer of technology from Federal laboratories to the private sector. These acts authorize Federal laboratories to cooperate with other governmental (Federal, State, local) entities and with the private sector (including universities and commercial firms) in R&D, and to license, transfer, or waive patent rights resulting from cooperative R&D. However, if exclusive rights in technical data are given by the government to the private sector, this could result in constraints on the dissemination of much unclassified Federal STI.

A 1987 executive order directs agencies to transfer technical data by allowing Federal contractors and grantees to own rights in computer software, engineering drawings, and technical data funded by Federal contract or grant.[8] This executive order and other proposals by the Office of Federal Procurement Policy[9] caused a vigorous debate over how to transfer government-funded technology and still preserve the public value of knowledge produced with taxpayer money.[10] Agencies such as the Department of Energy (DOE)and National Aeronautics and Space Administration (NASA) consider the open exchange of technical information to be fundamental to their research missions. A blanket transfer of rights in technical data could impair research in fields such as energy and space that generate technologies that are valuable assets with commercial potential. Too much emphasis on short-term commercialization of technology and related technical data could actually impair the U.S. long-term competitive posture.[11]

In many fields of science and technology, STI developed by other countries is increasingly important. Policies that severely restrict public access to unclassified Federal STI might encourage similar restrictions by other countries and frustrate the international exchange of STI. The thrust of DOE policy in energy research is to increase—not decrease—the equitable exchange of international energy STI. The DOE Office of Scientific and Technical Infor-

[4]See, for example, H.C. Relyea, *Striking A Balance: National Security and Scientific Freedom*, American Association for the Advancement of Science, Washington, DC, 1985; U.S. Congress,Office of Technology Assessment, *Science, Technology, and the First Amendment*, op. cit., footnote 1, ch. 4; and National Academy of Science, Panel on the Impact of National Security Controls on International Technology Transfer, *Balancing the National Interest: U.S. National Security Export Controls and Global Economic Competition* (Washington, DC: National Academy Press, 1987).

[5]Public Law 100-418, the "Omnibus Trade and Competitiveness Act of 1988," Aug. 23, 1988, Part II—Symmetrical Access to Technological Research, sec. 5171 (a) and (d).

[6]Public Law 96-480, Oct. 21, 1980.

[7]Public Law 99-502, Oct. 20, 1986.

[8]Executive Order 12591, Apr. 10, 1987.

[9]U.S. Office of Federal Procurement Policy, "Intellectual Property Rights Policy," draft, February 1989.

[10]For discussion of proposals to establish and transfer copyright in Federal computer software, see U.S. General Accounting Office, *Technology Transfer: Copyright Law Constrains Commercialization of Some Federal Software*, GAO-RCED-90-145 (Washington, DC: U.S. General Accounting Office, May 1990), and testimony of James W. Curlin, OTA, and other witnesses before an Apr. 26, 1990, hearing of the House Committee on Science, Research, and Technology, Subcommittee on Science, Research, and Technology. For general discussion of computer-related intellectual property issues, see U.S. Congress, Office of Technology Assessment, *Computer Software & Intellectual Property*, OTA-BP-CIT-61 (Washington, DC: U.S. Government Printing Office, March 1990), and *Intellectual Property in an Age of Electronics and Information*, OTA-CIT-302 (Washington, DC: U.S. Government Printing Office, April 1986).

[11]See, for example, the special issue, "Symposium on the Impact of Competitiveness," *Government Information Quarterly*, vol. 6, No. 1, 1989.

mation manages the Energy Technology Data Exchange (ETDE) under the auspices of the International Energy Agency. Canada, Denmark, Finland, France, the Federal Republic of Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom participate along with the United States.[12]

Participating countries send summaries of energy-related STI to DOE on a monthly or biweekly basis. DOE transmits them to participating countries for dissemination to their own researchers and policymakers. The ETDE includes about 7,500 biweekly updated STI entries and over 2 million entries in the retrospective file. The latter is available by online commercial vendors to research organizations, universities, and libraries within the participating countries. Online usage is divided roughly as follows: industry (71 percent); academia (15 percent); and government (14 percent).[13]

Numerous vendors sell or resell Federal STI databases, or include significant Federal STI in more comprehensive databases, to both domestic and international customers. Reduced availability of Federal STI to commercial vendors (and for that matter, not-for-profit vendors as well), coupled with reciprocal restrictions by other countries, would reduce the utility and value of comprehensive, subject-specific databases.

The challenge is to develop an STI dissemination policy that:

1. encourages U.S. researchers to employ all means, including electronic where appropriate, to facilitate access to and use of domestic and foreign STI; but at the same time
2. protects U.S. national security interests by controlling access to classified or narrowly defined militarily sensitive STI; and
3. encourages U.S. international competitiveness through:
   a. the open, reciprocal international exchange of STI,
   b. domestic transfer of federally funded technology from the Federal Government to the private sector where appropriate,
   c. protection of private-sector proprietary rights in technology and data (to the extent non-Federal funds are used), and
   d. domestic transfer of rights in technical data developed by or for the Federal Government (with Federal funding) to the private sector in narrowly defined areas where the benefits substantially outweigh the costs.[14]

Congress, the Office of Science and Technology Policy (OSTP), and the Office of Management and Budget (OMB) must reconcile their philosophical differences about the open flow of STI and provide guidance to the agencies. A balance is needed. This balancing should consider legislative proposals that focus on the open, unrestricted flow of Federal information[15] as well as legislation that would transfer federally supported technology and information to the private sector.[16] A balance must also consider statutes that promote information access

[12]International Energy Agency, *Energy Technology Data Exchange*, 1989 Annual Report, ETDE/OA-37 (Oak Ridge, TN: U.S. Department of Energy, Office of Scientific and Technical Information, 1989); International Energy Agency, *Introducing ETDE: An IEA Multilateral Information Program*, ETDE/OA-06-Rev. (Oak Ridge, TN: U.S. Department of Energy, Office of Scientific and Technical Information, June 1989).

[13]Ibid.

[14]For some proposed policy statements, see "Changing Federal Relationships in Intellectual Property," February 1989 draft, provided to OTA by CENDI, and "Policy Directions [in New Regulations on Patents and Copyrights]," May 1989 draft, provided to OTA by NASA.

[15]U.S. Congress, House, H.R. 2381, the "Information Policy Act of 1988," 101st Cong., 1st sess., May 16, 1989; H.R. 3695, the "Paperwork Reduction and Federal Information Resources Management Act of 1989," 101st Cong., 1st sess., Nov. 17, 1989; and S. 1742, the "Federal Information Resources Management Act of 1989," 101st Cong., 1st sess., Oct. 6, 1989; also see U.S. Congress, House, H.R. 2773, the "Freedom of Information Public Improvements Act of 1989," 101st Cong., 1st sess., June 28, 1989, that would redefine government records for FOIA purposes to cover all "computerized, digitized and electronic information."

[16]See U.S. Congress, Senate, S. 550, the "Department of Energy National Laboratory Cooperative Research and Technology Competitiveness Act of 1989," 101st Cong., 1st sess., Mar. 9, 1989, as amended Aug. 4, 1989, and included as the "Department of Energy National Competitiveness Technology Transfer Act of 1989," in Title XXXI, Part C of S. 1352, the "National Defense Authorization Act for Fiscal Years 1990 and 1991," Aug. 4, 1989. Also see U.S. Congress, Senate, Committee on Armed Services, *National Defense Authorization Act for Fiscal Years 1990 and 1991*, Report No. 101-81, 101st Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, July 19, 1989); and U.S. Congress, Senate, Committee on Energy and Natural Resources, *Department of Energy National Laboratory Cooperative Research and Technology Competitiveness Act of 1989*, Report No. 101-108, 101st Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, Aug. 4, 1989).

(such as the Freedom of Information Act (FOIA)[17]) and those statutes that tend to limit access.

The Defense Authorization Act of 1984 authorizes DoD to withhold certain unclassified but militarily sensitive and export-controlled scientific and technical information developed by or for DoD that would otherwise be accessible under FOIA.[18] NASA sought similar authority to withhold technical information about NASA-funded technologies. NASA policies also limit the dissemination of technical information to U.S. industry only, if it is likely to give the United States a competitive edge in commercializing NASA technology. But this information is currently available through FOIA requests, thus undermining NASA's policy. NASA has therefore sought to establish "significant potential for commercial use" as a statutory basis for FOIA exemption.[19]

A 1988 FOIA proposal supported by the Office of Science and Technology Policy and U.S. Department of Justice would have provided exemption for any STI that: 1) "was generated in a laboratory. . .owned and operated, in whole or in part, by the Federal Government"; 2) "has commercial value"; and 3) if disclosed under FOIA, "could be reasonably expected to cause harm to the economic competitiveness of the U.S."[20] This proposal was controversial and was challenged on several grounds, including:[21]

- the need for such a blanket exemption has not been established, since only a very small percentage of STI is commercially sensitive;
- such an exemption could set a dangerous precedent for undermining FOIA in other subject areas and by other kinds of agencies; and
- an exemption could encourage reciprocal actions by other countries that would undermine the international exchange of STI and hurt the U.S. R&D effort in the longer term.

In reviewing Federal policy, Congress needs to take into account the changing economic realities. The globalization of the economy means that an increasing percentage of U.S. domestic R&D companies operate under foreign ownership, just as many U.S. corporations now have their own foreign subsidiaries. Most of the largest U.S. companies operate globally, with research, manufacturing, and marketing distributed over many countries. Similar trends are evident in the commercial information sector, to the point where one cannot assume that a U.S. information vendor operates under domestic rather than foreign ownership, and vice versa. Under these conditions, the old approaches to controlling information access do not work.

Role of Governmentwide Dissemination and Archival Agencies in STI

As information changes from paper (and to a lesser extent microfiche) to electronic formats, the roles of the agencies with governmentwide dissemination and archival responsibilities require reconsideration. This is especially true for scientific and technical information, much of which is in digital form and may only be usable in electronic formats.

The major governmentwide agencies are: the Government Printing Office (GPO), responsible for printing, sales of selected documents by the Superin-

[17]For a detailed discussion of issues concerning an electronic FOIA, see J. Grodsky, "The Freedom of Information Act in an Electronic Age," in U.S. Congress, Office of Technology Assessment, *Informing the Nation: Federal Information Dissemination in an Electronic Age*, OTA-CIT-396 (Washington, DC: U.S. Government Printing Office, October 1988), pp. 207-236; also see Jerry J. Berman, "The Right to Know: Public Access to Electronic Information," in P.R. Newberg (ed.), *New Directions in Telecommunications Policy*, vol. 2, *Information Policy and Economic Policy* (Durham, NC: Duke University Press, 1989), pp. 39-69; H.H. Perritt, Jr., *Electronic Acquisition and Release of Federal Agency Information*, Report to the Administrative Conference of the United States, Oct. 1, 1988 (also see the related article by H.H. Perritt, Jr., in *Administrative Law Review*, vol. 41, 1989, pp. 253 ff.); and Thomas L. Susman, Chairman, American Bar Association, Committee on Government Information and Privacy, "Access to Electronic Information Under the Freedom of Information Act," draft report, Feb. 28, 1989. Also see statements of Ronald Plesser, Esq., Piper & Marbury, and Patti A. Goldman, Esq., Public Citizen, Inc., before a July 11, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture.

[18]U.S. Congress, Public Law 98-94, "Department of Defense Authorization Act of 1984," Sept. 24, 1983; also see W.R. Blados, "Controlling Unclassified Information," op. cit., footnote 2.

[19]See statement of Kenneth S. Pederson, Associate Administrator for External Relations, U.S. National Aeronautics and Space Administration, before a hearing of the House Committee on Science, Space, and Technology, Subcommittee on International Scientific Cooperation, July 19, 1989.

[20]U.S. Department of Justice, Office of Legal Policy, Office of Information and Privacy, "New FOIA Legislation Proposed to Promote U.S. Competitiveness," *FOIA Update*, vol. IX, No. 1, Winter 1988, pp. 1-2.

[21]See U.S. Congress, Senate, Committee on the Judiciary, Subcommittee on Technology and the Law, *Information Policy and Competitiveness, Hearing*, 100th Cong., 2d sess. (Washington, DC: U.S. Government Printing Office, Mar. 16, 1989).

The question is how to preserve and strengthen the ability of the governmentwide agencies to carry out their functions in a decentralized electronic environment.

tendent of Documents (SupDocs), and distribution of documents through the Depository Library Program (DLP); the National Technical Information Service (NTIS), the clearinghouse and sales outlet for technical documents; and the National Archives and Records Administration (NARA), concerned with archiving and long-term preservation of documents.[22]

Decentralized Nature of STI

It is clear that the creation, storage, and dissemination of STI is decentralized within the science agencies. This is because:

1. STI is voluminous, and agencies have difficulty in managing their own information base, much less another agency's data;
2. centralizing all STI in one data bank is neither cost-effective nor technically feasible at this time;
3. technical systems for creating, storing, and disseminating STI are typically closely tied to agency automation programs;
4. centralizing STI dissemination, even if technically feasible, could slow innovation and limit opportunities for improving efficiency in the agencies;
5. the diversity of STI needs and users among the Federal science agencies includes many varied disciplines and research areas;
6. the decentralized approach brings agency STI officials and the scientists and researchers who create and use the STI closer together; and
7. the economies-of-scale for electronic formats are achieved at lower levels of demand than for ink-on-paper printing.

Several agencies have data centers that are responsible for collecting, archiving, and disseminating databases, and much of these data are already in electronic formats. The major centers include: the National Space Science Data Center, National Climatic Data Center, National Oceanographic Data Center, National Geophysical Data Center, Earth Science Information Center, and Earth Resources Observation Systems Data Center. Several of the science agencies have their own central STI office (e.g., at NASA and DOE[23]) for STI documents and bibliographies, and most have infrastructure for handling STI, though it varies among the agencies (e.g., in terms of resources, staffing, visibility).

The question is how to preserve and strengthen the ability of the governmentwide agencies to carry out their functions in a decentralized electronic environment. Alternatives were considered by OTA in *Informing the Nation*,[24] by various congressional committees in hearings on NTIS, GPO, and the DLP,[25] and at a NARA conference on electronic recordkeeping.[26]

[22]The implications of electronic information for GPO, SupDocs, DLP, and NTIS are discussed in U.S. Congress, Office of Technology Assessment, *Informing the Nation*, op. cit., footnote 17, see esp. chs. 4-7, and 12. The implications for NARA are considered in National Academy of Public Administration, *The Effects of Electronic Recordkeeping on the Historical Record of the U.S. Government* (Washington, DC: National Archives and Records Administration, January 1989).

[23]See National Aeronautics and Space Administration, *The NASA Scientific and Technical Information System and How to Use It*, NASA SP-7073, Washington, DC, 1989; and Department of Energy, *The Role of the Office of Scientific and Technical Information in DOE's Scientific and Technical Information Program*, November 1988.

[24]U.S. Congress, Office of Technology Assessment, *Informing the Nation*, op. cit., footnote 17.

[25]See, for example, U.S. Congress, House, Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology, *National Technical Information Service*, Hearing, 100th Cong., 2d sess., U.S. Government Printing Office, Washington, DC, Feb. 24, 1988; U.S. Congress, House Committee on Science, Space, and Technology, *National Bureau of Standards Authorization Act for Fiscal Year 1989*, Report 100-673, Part 1, 100th Cong., 2d sess., U.S. Government Printing Office, Washington, DC, June 3, 1988; U.S. Congress, House, Committee on Energy and Commerce, *National Bureau of Standards Authorization Act for Fiscal Year 1989*, Report 100-673, Part 2, 100th Cong., 2d sess., U.S. Government Printing Office, Washington, DC, July 8, 1988; U.S. Congress, House, Committee on Administration, Subcommittee on Procurement and Printing, hearings on "Review of the Printing Chapters of Title 44 of the U.S. Code Due to the Changes in Electronic Information Format, Distribution, and Technology During the Last Decade," May 23-24 and June 28-29, 1989; U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, hearings on "Federal Information Dissemination Policies and Practices," Apr. 18, May 23, and July 11, 1989.

[26]National Archives and Records Administration, "Electronic Records: A Strategic Plan for the 1990s," Conference Summary and Recommendations, June 21-23, 1989, see especially the recommendations of the working group on information collection and dissemination.

Under the OTA scenario, the Federal science agencies retain primary responsibility for the storage and dissemination of STI collected by each agency. The science agencies would be governed by:

- their enabling statutes regarding STI;
- OSTP guidance provided under the National Science and Technology Policy, Organization, and Priorities Act of 1976, as possibly amended to give further congressional direction on STI policy;
- OMB guidance promulgated under the Paperwork Reduction Act (ch. 35 of Title 44 of the U.S. Code, as possibly further amended to provide congressional statutory direction on overall dissemination policy[27]);
- GPO (and Joint Committee on Printing) guidance under the printing chapters of Title 44, as possibly amended,[28] to ensure that the integrity of the GPO printing procurement program, SupDocs sales program, and DLP is maintained;
- NTIS guidance promulgated under the "National Technical Information Service Act of 1988"[29] to ensure that the integrity of the NTIS clearinghouse is maintained; and
- NARA guidance promulgated under the archival chapters of Title 44, as possibly amended, to ensure long-term preservation and access to STI.

This scenario is predicated on the assumption that OMB, GPO, NTIS, and NARA guidance would be generally consistent and compatible.

Roles of Science Agencies, NTIS, and GPO

One possible division of effort between the mission agencies and governmentwide agencies is outlined below using a hypothetical example of an electronic product—hydrology information of the U.S. Geological Survey (USGS) (e.g., trends in stream flows and reservoir and lake levels) issued on CD-ROM:

- USGS would notify GPO, NTIS, and NARA in advance of production and supply product information (e.g., size of the hydrology database, type of search-and-retrieval software, estimated cost and demand).
- GPO would decide whether the CD-ROM should be included in the SupDocs sales program, based on an estimate of demand beyond that being met by USGS direct sales. USGS could opt to use SupDocs as the primary sales outlet if the CD-ROM qualified.
- GPO also would determine whether the CD-ROM should be offered to depository libraries, and if so, how many libraries desired a copy of the CD-ROM.
- NTIS would decide whether the CD-ROM should be included in the NTIS clearinghouse and sales program.
- GPO and NTIS would, on a coordinated basis, make sure that the CD-ROM is cataloged and listed in appropriate governmentwide directories and bibliographic databases—whether or not it is sold by GPO and/or NTIS.[30]
- NARA would review the CD-ROM to determine long-term archival needs.
- GPO and NTIS would, again on a coordinated basis, advise USGS of their need for copies of the CD-ROM (to meet estimated SupDocs sales, depository library distribution, and NTIS sales needs).
- USGS would obtain CD-ROM production services in the manner that best meets its cost, quality, and turnaround requirements. This could be through an agency contractor, GPO contractor, GPO itself (if an inhouse service is offered), or NTIS contractor (if NTIS offers CD-ROM services).
- Wherever the USGS CD-ROM is produced, GPO and NTIS would ride the order for the number of additional copies required.

This example could apply to all offline electronic products, including optical disks, magnetic tapes and cassettes, and diskettes (hard and floppy). The large online electronic STI databases would be maintained by the agency data centers. But online directories and possibly subsets of data might be handled similarly to the CD-ROM illustration above. Some directories also could be disseminated on CD-ROM or other offline electronic formats.

[27]See H.R. 3695, op. cit., footnote 15; S. 1742, op. cit., footnote 15.

[28]See H.R. 3849, the "Government Printing Office Improvement Act of 1990," 101st Cong., 2d sess., Jan. 23, 1990.

[29]See U.S. Congress, Public Law 100-519, Subtitle B—National Technical Information Service, codified at 15 U.S.C. 3701 et. seq.

[30]See discussion of STI directories in ch. 5.

The future of NTIS and GPO will be influenced by the increasingly decentralized, competitive environment of the electronic information marketplace. Federal science agencies are rapidly installing electronic systems for their activities, including the collection, processing, and dissemination of STI (see the appendix for illustrations). NTIS and GPO will have to adapt to the reality that technology has changed and sometimes eliminated the distinctions between reports, publications, databases, and the like, and has blurred the distinctions between their roles and those of the agencies.

Most Federal STI will likely exist in electronic form as computerized electronic databases. Users will have a wide assortment of formats available, from printed reports to online information retrieval, printing-on-demand, and compact optical disk. NTIS and GPO will have to become more flexible, adaptive, creative, competitive, and user-oriented than they currently are.[31] Many users may continue to prefer the convenience of "one-stop" information shopping at NTIS or GPO, especially for hard-to-find documents (or their electronic equivalents). But the governmentwide dissemination programs will need to complement, not preempt, individual agency activities.

GPO and NTIS appear to be philosophically accepting this reality. The former Acting Public Printer has stated GPO's preference for the "Electronic GPO-Decentralized" approach.[32] In this scheme, GPO would continue its centralized conventional printing functions, but would aggressively plan for and implement electronic printing and dissemination services, working through a decentralized Federal electronic information environment.[33] Centralized conventional ink-on-paper printing would continue, with about three-quarters of all Federal printing done by or through GPO (although three-fourths of this is contracted out by GPO to commercial printing companies), and the rest at authorized agency printing plants. Decentralized agency electronic information dissemination would continue, with GPO offering a variety of electronic services to the agencies, but on a competitive, discretionary basis (in contrast to conventional ink-on-paper printing where GPO services must be used, unless an explicit exemption or exception is granted).[34]

The NTIS Director and Deputy Director have stated their commitment in principle to the "Electronic NTIS" alternative.[35] After years of declining demand for paper and microfiche products and the debate over privatization, Congress has directed NTIS to modernize. NTIS has developed a preliminary plan to increase its use of electronic formats, including CD-ROM, electronic bulletin boards, and, ultimately, an electronic document system that could accept electronic input from the source agencies and support electronic printing-on-demand. To be successful, NTIS will need to reduce per-unit costs, decrease the time delays between the existence of a document and its availability via

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[31]For further discussion, see U.S. Congress, Office of Technology Assessment, *Informing the Nation*, op. cit., footnote 17, ch. 12.

[32]U.S. Congress, Office of Technology Assessment, *Informing the Nation*, op. cit., footnote 17, ch. 4. Also see F.B. Wood, "Title 44 and Federal Information Dissemination—A Technology and Policy Challenge for Congress: A Viewpoint," *Government Publications Review*, vol. 17, 1990, pp. 1-5.

[33]See statement of Joseph E. Jenifer, Acting Public Printer, Government Printing Office, before a May 23, 1989, hearing and statement of Samuel B. Scaggs, Assistant Public Printer, Operations and Procurement, Government Printing Office before a June 29, 1989, hearing, Committee on House Administration, Subcommittee on Procurement and Printing. Also see statements of Joseph E. Jenifer, Acting Public Printer, before a Feb. 7, 1989, hearing of the House Committee on Appropriations, Subcommittee on the Legislative Branch, a July 11, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information, Justice, and Agriculture, and a Mar. 7, 1990, hearing of the Committee on House Administration, Subcommittee on Procurement and Printing. The new Public Printer stated a position on some of these issues before an Apr. 6, 1990, hearing of the Senate Committee on Appropriations, Subcommittee on the Legislative Branch. For other views and general discussion, see U.S. Congress, House, Committee on House Administration, Subcommittee on Procurement and Printing, *Title 44 U.S.C.—Review, Hearings*, 101st Cong., 1st sess., May 23, 24, and June 28, 29, 1989 (Washington, DC: U.S. Government Printing Office, 1989); statements of Fred B. Wood, OTA, before May 23, 1989, and Mar. 7, 1990, hearings of the Committee on House Administration, Subcommittee on Procurement and Printing; and OTA comments on S. 1742, the "Federal Information Resources Management Act of 1989," prepared for a Feb. 21-22, 1990, hearing of the Senate Committee on Governmental Affairs.

[34]This general approach is consistent with that of other countries such as New Zealand and Canada. See Canadian Communications Services Directorate, "Electronic Publishing Information Center," *Electronic Publishing Bulletin*, October 1989.

[35]U.S. Congress, Office of Technology Assessment, *Informing the Nation*, op. cit., footnote 17, chs. 5 and 12.

NTIS, and increase user awareness of NTIS services.[36]

Beyond this, NTIS must develop a clear strategic vision of its future, and a realistic, detailed implementation plan for getting there. During the 1980s, user demand for paper and microfiche documents in the basic NTIS archive steadily dropped; agency cooperation in providing documents to NTIS also declined. NTIS sales of electronic formats—the one bright spot—are likely to feel increasing pressure from agency, private sector, and GPO competition.[37]

Roles of NARA and DLP

The roles of NARA and the DLP deserve special attention. NARA might find that agency data centers can efficiently archive STI databases, releasing NARA from the need to retain physical control. Even if an agency or data center serves as the archive, NARA would help ensure that the system is cost-effective and meets data and technical standards (e.g., regarding longevity of storage media, conversion from one storage medium to another, and portability among different media and equipment). NARA could also assist the data centers in determining what should and should not be retained inhouse, with permanent STI archives retained by NARA. NARA needs to develop clear and workable agreements with the science agencies, and with NTIS and the Library of Congress (LOC), to ensure that archivable STI does not fall through the cracks.

Machine-readable materials are included within the legal definition of "record."[38] NARA has initiated a program for archiving electronic records that is now being extended to Federal STI. Permanent electronic records identified by NARA include, for example:[39]

- unique and important scientific and technical data resulting from observations of natural events or phenomena or from controlled laboratory or field experiments;
- natural resources data related to land, water, minerals, or wildlife; and
- geographic data used to map the surface of the earth.

NARA will need to assess the vast store of geographic, space, and earth sciences data with respect to archival needs and requirements—a task that becomes even more challenging with the rapid evolution of electronic storage and retrieval technologies and the poor condition of current data archives. Technological change means that large amounts of archived STI will be inaccessible and/or unusable to future generations of researchers unless standard information formats are developed and mandated. The long-term utility of STI requires that today's data and documents be retrievable with tomorrow's technologies.[40]

As for the Depository Library Program, there appears to be a consensus that electronic formats should be included, although there are differences of opinion over implementation. For several years now, the congressional Joint Committee on Printing (JCP), Depository Library Council, and the major library associations have argued that, as the Federal Government makes increasing use of electronic information, the DLP must also include electronic information, lest the integrity of the program be

[36]See National Technical Information Service, Annual Report to the Congress from the Secretary of Commerce, *The National Technical Information Service: Operations, Audit, and Modernization*, January 1989; also see U.S. Congress, Office of Technology Assessment, *Informing the Nation*, op. cit., footnote 17, chs. 5 and 12; C.R. McClure, P. Hernon, and G.R. Purcell, *Linking the U.S. National Technical Information Service With Academic and Public Libraries* (Norwood, NJ: Ablex Publishing Corp., 1986). Also see Statement of Joseph F. Caponio, Director, National Technical Information Service, before a July 13, 1989, hearing of the National Commission on Libraries and Information Science.

[37]For further discussion, see the statements of Fred B. Wood, OTA, Harold B. Shill, West Virginia University, and Jean Mayhew, United Technologies Corp., before a Mar. 8, 1990, hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology. Also see C.F. McClure, "The Future of the National Technical Information Service: Issues and Options," Jan. 20, 1990, contractor paper prepared for OTA. For background discussion of the NTIS privatization debate, see F.B. Wood, "Proposals for Privatization of the National Technical Information Service: A Viewpoint," *Government Publications Review*, vol. 15, 1988, pp. 403-409 (which is based on testimony presented at a Feb. 24, 1988, hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology).

[38]44 U.S.C. 3301.

[39]U.S. National Archives and Records Administration, "Managing Electronic Records: An Instructional Guide," draft, no date, pp. 15-17; also see Michael L. Miller, "Appraisal and Disposition of Electronic Records," National Archives and Records Administration, March 1988 draft; and June 13, 1989, cooperative agreement between NARA and NOAA.

[40]The U.S. General Accounting Office is conducting audits of the major data archives maintained by Federal science agencies. See U.S Government Accounting Office, *Space Operations: NASA Is Not Properly Safeguarding Valuable Data From Past Missions*, Report to the Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, IMTEC-90-1 (Washington, DC: GAO, March 1990). Subsequent reports will address NOAA and USGS data archives.

The long-term utility of STI requires that today's data and documents be retrievable with tomorrow's technologies.

eroded.[41] In May 1989, GPO's General Counsel ruled that it has legal authority to distribute agency publications in electronic format to depository libraries, thereby clarifying a 1982 opinion that was widely interpreted as limiting the DLP to traditional (paper and microfiche) formats.[42] This apparently ended a long conflict between GPO and the JCP about whether the depository library provisions of Title 44 apply to government publications regardless of format.[43]

The differences between the JCP, OMB, and Information Industry Association (IIA) appear to have narrowed. OMB supports the voluntary participation of agencies in DLP electronic dissemination, and is willing to consider requiring that some agency electronic information products be provided to depository libraries.[44] The IIA now supports the inclusion of some electronic formats in the DLP, but with reservations about online dissemination and financing, and suggests testing alternative mechanisms such as vouchers, bulk rate and off-peak contracts, user charges, and cost-sharing.[45] In Congress, the House Appropriations Subcommittee on the Legislative Branch has supported distribution of CD-ROMs to depository libraries, and may be open to distributing other electronic formats, including online services, although questions of cost, demand, technical feasibility, and administrative responsibility have not been resolved.[46] These questions, among others, are being addressed through the DLP electronic pilot projects now being implemented.[47]

Two of the DLP pilot projects cover Federal STI. The first involves the distribution of the Environmental Protection Agency's "Toxic Release Inventory (TRI)" to depository libraries. TRI includes details on the location, storage, emissions, and waste treatment and transfer for over 300 toxic chemicals. EPA is disseminating TRI to the public online via the National Library of Medicine computer center, in magnetic tape format via the NTIS and GPO sales programs, and in computer output microfiche and CD-ROM formats through selected libraries, including all 1,400 depository libraries.[48] The second

[41]See statements of D. Kaye Gapen, Dean of Libraries, University of Wisconsin (on behalf of the Association of Research Libraries), and Sandra McAnich, Head, Government Documents, University of Kentucky Libraries (on behalf of the Government Documents Roundtable, American Library Association), before a May 24, 1989 hearing of the House Administration Committee, Subcommittee on Procurement and Printing. Also see the statement of D. Kaye Gapen, on behalf of the American Library Association and Association of Research Libraries, before a Feb. 7, 1989, hearing of the House Committee on Appropriations, Subcommittee on the Legislative Branch.

[42]Memorandum from GPO General Counsel to Acting Public Printer, "GPO Dissemination of Federal Agency Publications in Electronic Format," May 22, 1989.

[43]See U.S. Congress, Joint Committee on Printing, *Provision of Federal Government Publications in Electronic Format to Depository Libraries*, Report of the Ad Hoc Committee on Depository Library Access to Federal Automated Databases (Washington, DC: U.S. Government Printing Office, 1984); U.S. Congress, Joint Committee on Printing, *An Open Forum on the Provision of Electronic Federal Information to Depository Libraries*, 99th Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, 1985); Joint Committee on Printing resolutions of Apr. 8, 1987, June 17, 1987, and June 29, 1988 regarding GPO, depository libraries, and electronic formats; and letter from Honorable Frank Annunzio, Chairman, Joint Committee on Printing, to Honorable Ralph E. Kennickell, Jr., Public Printer, Mar. 25, 1988.

[44]See Office of Management and Budget, "Second Advance Notice of Further Policy Development on Dissemination of Information," *Federal Register*, vol. 54, No. 114, June 15, 1989, pp. 25554-25559.

[45]See statement of Kenneth B. Allen, Senior Vice President, Government Relations, Information Industry Association, accompanied by Peyton R. Neal, Jr., Chair, IIA Government Printing Office Committee, before a May 24, 1989, hearing of the House Committee on Administration, Subcommittee on Procurement and Printing. Also see a somewhat more critical statement of Paul P. Massa, President, Congressional Information Services, Inc., before a July 13, 1989, hearing of the National Commission on Libraries and Information Science. One private vendor, Legi-Slate, Inc., has offered to provide electronic online dissemination of selected congressional information to depository libraries at bulk rate discounted prices, based in part on the results of a successful 5 1/2 month pilot test with 51 depository libraries. The same concept could be used by other vendors with respect to other types of Federal information, including STI. See Legi-Slate, "Pilot Project Evaluation Preliminary Summary," Jan. 8, 1989.

[46]U.S. Congress, Committee on Appropriations, *Legislative Appropriations Bill, 1989*, Report to accompany H.R. 4487, Report No. 100-621, 100th Cong., 2d sess., 1988. Also see statement of Honorable Viz Fazio, Chairman, House Committee on Appropriations, Subcommittee on the Legislative Branch, before a June 28, 1989, hearing of the House Committee on Administration, Subcommittee on Printing and Procurement.

[47]The U.S. General Accounting Office is conducting an evaluation of the research methodology of the electronic pilot projects. See May 8, 1989, letter from Donald E. Fossedal, Assistant Public Printer, U.S. Government Printing Office, to Richard Fogel, Assistant Comptroller General, U.S. General Accounting Office.

[48]Statement of Edward J. Hanley, Director, Office of Information Resources Management, U.S. Environmental Protection Agency, before a hearing of the Subcommittee on Government Information, Justice, and Agriculture, House Committee on Government Operations, Apr. 18, 1989.

project involves the U.S. Department of "Energy Data Base" (EDB). DOE has proposed to provide depository libraries with online access to the EDB.[49] (See the appendix for further discussion of the EDB pilot project.)

In addition, GPO is seeking suggestions from private vendors on how they might participate in electronic dissemination to depository libraries. Industry interest appears to be high. Finally, Federal agencies also seem generally supportive of an electronic role for the DLP, but have unanswered questions and concerns about selection procedures, financing, and user support for electronic format items included in the DLP.[50]

The remaining DLP issues concern cost and financing, especially for online dissemination. CD-ROM and offline formats are gaining acceptance as cost-effective alternatives to paper and microfiche. It is likely that most depository libraries would select only a relatively small portion of total Federal STI—as is the case with Federal information in general—and would more typically refer users to STI data centers and existing archives. This would require that depository libraries have efficient access to directories, indices, and bibliographies of the Federal STI, rather than to the STI itself.

Alternatively, a small number of depository libraries could be designated as STI depositories. These libraries would include a large amount of STI in their collections, and would serve as a shared resource for local and regional libraries. STI depositories could be strategically located in areas of concentrated scientific and technical activity where the local community is committed to building its R&D base. STI depositories would have to have the technical capabilities to use all electronic formats—online, CD-ROM, and diskette. This possibility could be explored in depth as part of an overall reexamination of the DLP.

Funds for STI dissemination at depositories could come from several sources, with a portion funded through the DLP direct appropriation, a portion by the Federal science agencies (e.g., for free copies of selected agency CD-ROMs and fee reductions or waivers for online access to selected agency databases), a portion by the depository libraries (e.g., for microcomputers, CD-ROM readers, and modems), and a part by the library users (e.g., for telecommunication line charges). The libraries could have discretion over how the appropriated funds are spent. For example, libraries could be issued vouchers for access to online STI bibliographic databases. These funds could be expended on a mix of government, commercial, and not-for-profit databases, depending on user needs. Vouchers might also be used for library purchase of equipment needed to support electronic dissemination, and for subsidy of telecommunication or electronic printing charges incurred by students or others with limited means.[51]

Overall, an estimated 9 to 10 million persons use depository libraries each year. Academic libraries represent about 55 percent of all depository libraries. Students and faculty account for 85 percent of academic library users. Students and professional, technical, and managerial persons together represent about 77 percent of public depository library users.[52] Thus, depository users are likely to be a ready market for Federal STI in electronic formats, and open to technical and institutional innovation in information dissemination. The electronic pilot projects will shed more light on this prospect.[53]

[49] U.S. Congress, Joint Committee on Printing, "Dissemination of Information in Electronic Format to Federal Depository Libraries: Proposed Project Descriptions," June 1988.

[50] See statement of Forrest B. Williams, Branch Chief, Data User Services Division, U.S. Bureau of the Census, before a July 13, 1989, hearing of the National Commission on Libraries and Information Science.

[51] Representatives of library associations are concerned about proposals for sharing costs of online or other electronic dissemination. Depository libraries already spend several dollars (in building, equipment, and staff costs) for every dollar spent by the Federal Government on documents, and oppose shifting more costs of dissemination to the libraries. See statements of Cheryl Rae Nyberg, American Association of Law Libraries, Merrily Taylor, Association of Research Libraries, and Katherine F. Mawdsley, American Library Association, before a Mar. 8, 1990, hearing of the Committee on House Administration, Subcommittee on Procurement and Printing.

[52] C.R. McClure and P. Hernon, *Users of Academic and Public GPO Depository Libraries* (Washington, DC: U.S. Government Printing Office, 1989).

[53] For further discussion of depository library alternatives, see U.S. Congress, Office of Technology Assessment, *Informing the Nation*, op. cit., footnote 17, ch. 7; and Association of Research Libraries, *Technology and U.S. Government Information Policies: Catalysts for New Partnerships* (Washington, DC: October 1987). Also see statements of D. Kaye Gapen before the House Committee on Administration and House Committee on Government Operations, op. cit., footnote 41; and statements of Vicki W. Phillips, Chair, Depository Library Council to the Public Printer, Patricia Glass Schuman, President, Neal-Schuman Publishers, Inc. (on behalf of the American Library Association), and Bruce M. Kennedy, Head, Reference Department, Georgetown University Law Center (on behalf of the American Association of Law Libraries) before a July 13, 1989, hearing of the National Commission on Libraries and Information Science.

Chapter 5

Framework for a Presidential Initiative on Scientific and Technical Information

An important part of a strategy for scientific and technical information (STI) is leadership—leadership from the science and technology community, Congress, Federal science agencies, and the Executive Office of the President, including the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP). Leadership is necessary to reach a workable consensus on the outstanding issues of STI dissemination and access discussed in chapters 3 and 4. Leadership is needed to improve interagency coordination and agency organization for STI. How can this leadership be provided? The key is presidential leadership on STI. This can be done in several ways:

1. strengthen the OSTP role;
2. establish an OSTP advisory committee and an interagency coordinating committee on Federal STI;
3. redefine OSTP-OMB working relationships regarding STI;
4. upgrade STI dissemination functions within agency R&D and Information Resources Management programs;
5. develop technical standards and directories for STI dissemination;
6. launch an STI education initiative; and
7. improve international STI exchange programs.

Strengthening the OSTP Role

Congress intended that OSTP be the focal point for STI leadership in the executive branch, and that the OSTP Director (who serves as the President's Science Advisor) designate STI as a priority concern of OSTP.[1] The "National Science and Technology Policy, Organization, and Priorities Act of 1976,"[2] OSTP's organic statute, addresses STI in the declaration of congressional policy. Congress was concerned that STI had received little attention.[3] The Act recognizes that "effective management and dissemination of scientific and technological information" is part of the U.S. science and technology base. It states that "Federal departments, agencies, and instrumentalities should establish procedures to ensure among them the systematic interchange of scientific data and technological findings developed under their programs."[4] The legislative intent was to include STI in the OSTP mission implicitly.[5] STI is mentioned in the charter of a President's Committee on Science and Technology that was to consider, among other things, "improvements in existing systems for handling scientific and technical information on a governmentwide basis, including consideration of the appropriate role to be played by the private sector in the dissemination of such informa-

[1]For a discussion of legislative history and options, see U.S. Congress, House, Committee on Science and Technology, Subcommittee on Science, Research, and Technology, *Optimizing the Value of U.S. Scientific and Technical Information: Legislative Options*, report prepared by the Congressional Research Service (Washington, DC: October 1978). For general discussion of science advice in the White House, see W.G. Wells, Jr., "Science Advice and the Presidency, 1933-1976," dissertation, School of Government and Business Administration, The George Washington University, Washington, DC, 1977; W.T. Golden (ed.), *Science Advice to the President* (New York: Pergamon Press, 1980); W.T. Golden (ed.), *Science and Technology Advice to the President, Congress, and Judiciary* (New York: Pergamon Press, 1988); G.J. Knezo, "Suggestions for Collection of Archival Information Pertaining to Presidential Science Advisory Bodies Before 1976," memorandum, Congressional Research Service, Nov. 15, 1989; and statements of Fred B. Wood, OTA; Joseph G. Coyne, U.S. Department of Energy; and Charles R. McClure, Syracuse University, before an Oct. 12, 1989, hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology.

[2]U.S. Congress, Public Law 94-282, May 11, 1976.

[3]According to most observers, the peak of White House interest in STI occurred in the Kennedy and Johnson Administrations, during which time presidential science advisory bodies issued several landmark studies on Federal STI. See, for example, J.H. Crawford, Jr., G. Abdian, W. Frazer, S. Passman, R.B. Stegmaier, Jr., and J. Stern, *Scientific and Technical Communications in Government*, Task Force Report to the President's Special Assistant for Science and Technology (Washington, DC: U.S. Department of Commerce, April 1962); and Federal Council for Science and Technology, Committee on Scientific and Technical Information, *Recommendations for National Document Handling Systems in Science and Technology* (Washington, DC: U.S. Department of Commerce, November 1965).

[4]Public Law 94-282, sec. 102(a)(5)(c) and sec. 102(c)(10).

[5]Earlier legislative proposals addressed STI in more detail. The House committee reports made clear that STI was to have a high priority. See, for example, U.S. Congress, House, Committee on Science and Technology, *National Science and Technology Policy and Organization Act of 1975*, Report No. 94-595, 94th Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, Oct. 29, 1975).

The low profile of OSTP with respect to governmentwide STI policy has, in effect, ceded the dominant executive branch policy role to the Office of Management and Budget.

tion."[6] This provision of the law has not been implemented.[7]

OSTP has provided a modicum of staff attention to STI matters, and has encouraged the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) in some STI matters. The Council, established under Title IV of the Act, is made up of the OSTP Director (chairman), and representatives of the Federal science and technology agencies. The Council created the Committee on Earth Sciences, which has endorsed the work of the Interagency Working Group on Data Management for Global Change. This working group is addressing some of the STI technical and policy issues as they relate to earth sciences and global change. FCCSET also has supported work in the areas of high-performance computing and networking, which relate to STI dissemination.[8] But, neither OSTP nor the FCCSET has given much attention to the dissemination of STI documents or bibliographic databases, to issues involving agencies like the National Technical Information Service (NTIS) and Government Printing Office (GPO) that are responsible for disseminating such materials, or to governmentwide information dissemination issues that relate to STI.

The low profile of OSTP with respect to governmentwide STI policy has, in effect, ceded the dominant executive branch policy role to the Office of Management and Budget. OMB has used its authority under the Paperwork Reduction Act to promulgate governmentwide information policy that covers STI as well as most other types of Federal information (see ch. 3). OSTP has only minimally used its authority under the National Science and Technology Policy Act to get involved in STI policy. Thus the activities of OMB—not OSTP—have had by far the largest impact on STI, and especially on dissemination.

A strengthened OSTP role would help ensure that the special needs and problems of STI are considered, and that the contribution of STI to broader national goals is identified and realized. A stronger role should also improve interagency coordination on STI. The OSTP director may, on his own initiative, give a higher priority to STI matters. This might involve the assignment of OSTP staff to STI issues, and the formal recognition of STI functions within each of the major OSTP programmatic areas. But even so, Congress could seriously consider amending the law to provide stronger congressional guidance. This could be done by adding STI as an explicit, required area of OSTP responsibility and to FCCSET's charter, and perhaps by authorizing OSTP funds specifically for STI activities.[9]

OSTP could prepare and issue a strategic plan on STI, with the advice and assistance of advisory committees and agency officials, as was done in high-performance computing. This recently issued computing plan[10] states the goals, rationale, actions, responsibilities, and budget for implementing the U.S. high-performance computing and networking program. Program leadership is assigned to OSTP, assisted by an FCCSET Committee on Computer Research and Applications and an advisory panel selected by and reporting to the OSTP Director. The FCCSET Committee is responsible for interagency planning and coordination, technology assessment, and preparation of policy recommendations and annual progress reports to OSTP. The advisory panel

[6] Public Law 94-282, sec. 303(a)(2).

[7] For a general review of OSTP performance, see G.J. Knezo, *Analysis of the Office of Science and Technology Policy*, CRS Report No. 88-205 SPR (Washington, DC: Congressional Research Service, February 1988) and *White House Office of Science and Technology Policy: An Analysis*, CRS Report No. 89-689 SPR (Washington, DC: Congressional Research Service, November 1989).

[8] See U.S. Office of Science and Technology Policy, Executive Office of the President, *A Research and Development Strategy for High Performance Computing*, Committee on Computer Research and Applications, Federal Coordinating Council on Science, Engineering, and Technology (Washington, DC: Executive Office of the President, Nov. 20, 1987); and U.S. Office of Science and Technology Policy, Executive Office of the President, *The Federal High Performance Computing Program* (Washington, DC: Executive Office of the President, Sept. 8, 1989).

[9] Congress is considering this approach for high-performance computing. S. 1067, the "High-Performance Computing Act of 1990," would mandate and authorize funding for OSTP and FCCSET activities in this area.

[10] U.S. OSTP, *High Performance Computing Program*, 1989, op. cit., footnote 8.

Strategically, the most important STI role for OSTP may be its visible leadership on STI issues coupled with the assessment of STI issues from an integrated cross-cut perspective across agencies and disciplines.

will include scientific, academic, and industry experts, and will provide the OSTP Director and FCCSET with independent assessments of program progress, relevance, and balance. A similar organizational approach could be used for "a Federal STI Program."

An STI strategic plan could, even in its early stages, serve as a focal point for involving OSTP in the ongoing legislative efforts to amend the Paperwork Reduction Act, Printing Act, Depository Library Act, and other statutes that affect Federal STI. OSTP leadership could help develop a strategic vision of: 1) the role of the Federal R&D agencies, NTIS, and GPO in STI dissemination; 2) principles of STI dissemination that encourage use of Federal STI; and 3) updated policies on the open flow of Federal STI that reflect rapidly changing global economic, political, and technological realities.

An STI strategic plan also could integrate STI activities across the several existing Federal policies and programs to encourage technology transfer and industrial innovation. These include, for example:[11]

- the Federal Laboratory Consortium for Technology Transfer, in which about 300 Federal labs participate, that promotes utilization of technical knowledge developed by or for Federal labs;
- The Offices of Research and Technology Applications, located at each Federal lab, that identify technologies and ideas with potential outside application; and
- the Small Business Innovation Development program, that encourages technology development by small companies, including use of federally developed technology and STI in commercial applications.

Other programs encourage a variety of joint ventures and cooperative R&D agreements between the Federal Government, universities, and/or private industry. The proliferation of technology transfer activities has made the need for an STI cross-cut even greater.

Strategically, the most important STI role for OSTP may be its visible leadership on STI issues coupled with the assessment of STI issues from an integrated cross-cut perspective across agencies and disciplines. OSTP leadership would require its collaboration with various STI constituencies—in the science agencies, in Congress, in academia and private industry—for ideas, feedback, and dialog. The last time this happened on STI was in the 1960s.[12]

The National Science Foundation (NSF) supported several STI studies during the 1980s that identified STI problems and possible policy solutions.[13] At that time, OSTP lacked the interest, staff, and high-level support to followup on the STI studies of NSF and other groups. OSTP could not itself perform major STI policy research for lack of resources. But its active involvement can go a long way toward supporting the efforts of others. OSTP certainly can be expected to conduct policy planning

[11]For a general overview, see W.H. Schacht, *Technology Transfer: Utilization of Federally Funded Research and Development*, IB 85031, and *Industrial Innovation: Debate Over Government Policy*, IB 84004 (Washington, DC: Congressional Research Service, Aug. 7, 1989).

[12]Presentation of A.A. Aines, former Acting Chairman, Committee on Scientific and Technical Information, White House Office of Science and Technology, at a CENDI meeting, Dec. 12, 1989.

[13]NSF-sponsored studies include: A.H. Teich and J.P. Weinberg, *Issues in Scientific and Technical Information Policy* (Washington, DC: American Association for the Advancement of Science, Dec. 28, 1982); T.K. Bikson, B.E. Quint, and L.L. Johnson, *Scientific and Technical Information Transfer: Issues and Options* (Santa Monica, CA: Rand Corp., March 1984); S. Ballard, C.R. McClure, T.I. Adams, M.D. Devine, L. Ellison, T.E. James, Jr., L.L. Malysa, and M. Meo, *Improving the Transfer and Use of Scientific and Technical Information: The Federal Role* (Norman, OK: Science and Public Policy Program, University of Oklahoma, September 1986); J.D. Eveland, *Scientific and Technical Information Exchange: Issues and Findings* (Washington, DC: Division of Policy Research and Analysis, NSF, March 1987); NSF Division of Policy Research and Analysis, *Scientific Information Exchange: A Status Report on Converting New Fundamental Knowledge Into Competitive Products* (Washington, DC: NSF, April 1987); and NSF Division of Policy Research and Analysis, *Federal Technology Transfer: Mechanisms and Agency Practices* (Washington, DC: NSF, May 1987).

and assessments based on the best available STI research.[14]

The extensive, multi-year debate leading up to the establishment of OSTP in May 1976 reflected a strong consensus among leading scientists and engineers on the importance of these OSTP responsibilities to STI.[15] This was followed in 1976-77 by a vigorous debate over OSTP's functions in the Carter Administration. Few of the numerous innovative proposals brought forward[16] were implemented due to President Carter's decision to downsize the entire Executive Office of the President, including OSTP.[17] The Bush Administration (and the appointment of Dr. D. Allan Bromley as the Director of OSTP) is the first real opportunity in 12 years for OSTP to carry out the congressional intent of OSTP's organic Act and fulfill the vision of the scientific and technical community—including a leadership role in Federal STI.

Establishing Advisory Committees on STI

The success of the Committee on Scientific and Technical Information (COSATI) is frequently cited as evidence of the potential effectiveness of high-level advisory bodies. COSATI was formed in 1963 by the former Office of Science and Technology (created in 1962 by executive order) and its President's Science Advisory Committee (PSAC). COSATI and PSAC provided high-level executive branch leadership on STI.[18] With a change of administrations, COSATI was transferred from the Office of Science and Technology to NSF in 1971 and abolished in 1972. The Office of Science and Technology itself was abolished in 1973.[19] OSTP was established by statute in 1976. The new OSTP Director has recently created a President's Council of Advisors on Science and Technology—the equivalent of PSAC—under the President's statutory authority. Functions of the new President's Council of Advisors could be extended to STI and the creation of advisory subgroups such as COSATI.

OSTP could use FCCSET to help agency STI managers get higher priority for information dissemination and utilization as part of agency R&D programs that collect or create the STI.

Two STI advisory bodies are justified. A COSATI of advisors and experts could report to the OSTP Director. This group might include representatives from major segments of the science and technology community concerned with STI: scientists, scholars, information specialists, large and small business leaders, librarians, State/local government officials, consumer and labor leaders, and the like. A second advisory body comprised entirely of agency STI officials could be established under FCCSET. This group could include representatives from a cross-section of Federal science agencies, including the major Federal science data centers and document clearinghouses, and the governmentwide dissemination and archival agencies.

[14]Both the outreach and policy assessment roles of OSTP are addressed at a general level throughout the enabling statute and legislative history. See Public Law 94-282, op. cit., footnote 2; U.S. Congress, House, Committee on Science and Technology, *National Science and Technology Policy and Organization Act of 1975, Report*, 94th Cong., 1st sess., Rep. No. 94-595 (Washington, DC: U.S. Government Printing Office, Oct. 29, 1975); U.S. Congress, House, Committee on Science and Technology, *Science and Technology Policy, Conference Report*, 94th Cong., 2d sess., Rep. No. 94-1046 (Washington, DC: U.S. Government Printing Office, Apr. 26, 1976).

[15]See, for example, U.S. National Academy of Sciences, *Science and Technology in Presidential Policymaking: A Proposal* (Washington, DC: National Academy Press, June 1974).

[16]See, for example, statements of Lewis M. Branscomb, "Science and Technology Issues: A Framework," June 14, 1976; Harold Brown, "Science and Technology Organization in the Executive Office of the President," Aug. 23, 1976; and F.B. Wood, V. Coates, J. Coates, R. Ericson, and J. Logsdon, "Early Warning and Policy Assessment Capability To Support Presidential Policymaking/Decisionmaking," Jan. 3, 1977; prepared for the Jimmy Carter Presidential Transition Team.

[17]OSTP was reduced to a minimal staff level of about 15 persons. However, it could have been worse. For example, the White House Office of Telecommunications Policy was abolished, and its functions transferred to the Departments of Commerce and State and the Federal Communications Commission.

[18]See, for example, President's Advisory Committee, *Science, Government, and Information: The Responsibilities of the Technical Community and the Government in the Transfer of Information* (Washington, DC: U.S. Government Printing Office, Jan. 10, 1963).

[19]Thomas E. Pinelli, "Chronology of Selected Reports, Related Studies, and Significant Events Concerning Scientific and Technical Information in the United States," May 1989 draft. For other historical perspectives, see A. Bishop and M.O. Fellows, "Descriptive Analysis of Major Federal Scientific and Technical Information Policy Studies," in C.R. McClure and P. Hernon, *United States Scientific and Technical Information Policies: Views and Perspectives* (Norwood, NJ: Ablex Publishing Corp., 1989), pp. 3-55; and A.A. Aines, "A Visit to the Wasteland of Federal Scientific and Information Policy," *Journal of the American Society of Information Science*, vol. 35, May 1984, pp. 179-184.

OSTP could ensure that Federal science agencies have a role in the STI policymaking process at OMB. OSTP could collaborate with OMB on major initiatives to improve the management of Federal information systems, including agency STI systems.

The lack of an equivalent to COSATI, or a formal FCCSET advisory body on STI, in part led to the creation of CENDI (Commerce, Energy, NASA, NLM, Defense Information). CENDI is an interagency group established by several Federal science agencies (NTIS, DOE, NASA, DTIC, and NLM) to address STI issues. The CENDI agencies represent over 90 percent of the Federal R&D budget. CENDI supports a strong OSTP and FCCSET role in STI.

Compared to CENDI, an FCCSET committee on STI could be upgraded in several ways. First, its scope could be expanded to include the data side of STI as well as the bibliographic and document side on which CENDI now concentrates. Second, the FCCSET committee's membership could be expanded to include other Federal agencies with major STI functions (e.g., USGS, NOAA, USDA, and EPA) that are not presently included in CENDI. Third, staff support and funding could be expanded beyond that now available to CENDI. CENDI has undertaken several new projects in the areas of standards, cataloging, indexing, and technology assessment, but has no regular means of support (participating agencies make voluntary contributions). Fourth, the FCCSET committee could assert leadership in educating government executives on the importance of STI dissemination and governmentwide STI strategies, in a much more vigorous manner than appears possible through CENDI. Fifth, the FCCSET committee could establish strong working relationships with other interagency groups.

Improved coordination is urgently needed among the interagency groups involved in Federal STI, including:

- CENDI;
- Interagency Working Group on Data Management for Global Change;
- Interagency Coordinating Committee on Digital Cartography;
- Special Interest Group on CD-ROM Applications and Technology;
- Federal Publishers Committee;
- Interagency Panel on Numerical Data;
- Interagency Advisory Council on Printing and Publishing; and
- Federal Library and Information Center Committee.

OSTP could take a leadership role on an FCCSET STI committee, to help further offset the natural tendency of all interagency groups to reflect agency-specific rather than governmentwide concerns. OSTP also could help ensure, through FCCSET, that the various interagency groups have adequate administrative and financial support, balanced membership, and an audience for the fruits of their labors. If the FCCSET committee is effective, some of the other interagency groups may no longer be needed.

OSTP could use FCCSET to help agency STI managers get higher priority for information dissemination and utilization as part of agency R&D programs that collect or create the STI. R&D managers have a strong tendency to emphasize the conduct of the research itself, rather than the effective use of research results. OSTP could work with FCCSET to help individual agency STI programs contribute to governmentwide priorities, such as the global change program.

Redefining OSTP-OMB Working Relationships on STI

OMB has a dominant role in executive branch information policy and oversight. The OMB Office of Information and Regulatory Affairs has devoted little attention specifically to STI, and some within OMB strongly support a reactivated STI role for OSTP. But, even if OSTP gives priority to STI, OMB will continue to be a major player for two reasons: first, OMB guidance on general government information policy will also apply to STI (e.g., Circular A-130), unless STI is granted a blanket exemption, an unlikely prospect; second, OMB will still be the primary decisionmaker on budgets for Federal science agencies—including resources allocated to STI.

A new OSTP-OMB working relationship on Federal STI is necessary. OSTP could actively participate in the drafting and public comment

process for revisions to OMB Circular A-130 and other circulars that affect STI. OSTP could ensure that Federal science agencies have a role in the STI policymaking process at OMB. OSTP could collaborate with OMB on major initiatives to improve the management of Federal information systems, including agency STI systems. Many criticisms of Federal information systems apply to STI as well. Federal agencies have been criticized for not paying enough attention to the users of Federal information and involving users from the outset of project planning. OSTP and OMB could encourage user outreach activities and provide guidance to the agencies on how to improve outreach.

OMB issues an annual bulletin on "Federal information systems and technology planning" that directs agencies in the preparation of strategic plans. These are developed as part of agency and governmentwide 5-year plans. OSTP could suggest topics for special attention. In 1988, OMB asked agencies to provide details on electronic mapping databases (otherwise known as digital cartographic, geographic, or land information systems). In 1989, OMB asked agencies to provide information on image processing systems and electronic data interchange.[20] These topics all relate to STI. Other possible STI-related topics include: high-density data storage systems; expert systems for information retrieval; machine translation (of foreign language publications); and gateway technologies for multiple remote database access.

OSTP and OMB could help ensure that each Federal science agency is aware of and carefully examines state-of-the-art activities of other agencies. For example, the Defense Technical Information Center (DTIC) prepared a year 2000 strategic plan and is implementing it.[21] DTIC is the clearinghouse for STI developed by or for the Department of Defense (DoD). DTIC operates: an online research database (DROLS = Defense Research On-Line Search); an intelligent gateway to DoD and some other online databases (that eventually will be extended to many Federal agency and commercial databases); and a prototype electronic document system (that uses scanners, optical disks, supermicrocomputers, intelligent work stations, and laser printers for storing and disseminating DoD technical documents).

Other OSTP-OMB joint activities might include:

- cosponsorship of ad hoc interagency committees on specific priority topics, such as improved indexing of Federal STI and other types of information (OMB already has proposed a committee on this topic), management of very large databases (e.g., the Earth Observing System), and quality control of standard reference data (on physical, chemical, and engineering properties).
- cosponsorship of a continuing dialog—through meetings, committees, conferences, and other means—between agency R&D and STI managers to ensure that the Federal investment in STI best serves the R&D user community;
- coordination on appointments to any OSTP and OMB outside advisory committees that may be established on STI or Federal information;
- cofunding, directly or with agency support, of research projects in targeted cross-cut areas such as user training and STI education;
- OSTP participation in OMB-sponsored interagency groups (e.g., the Interagency Coordinating Committee on Digital Cartography[22]) and vice versa; and
- cosponsorship of conferences that bring together all elements of the STI community, from agencies to libraries to vendors.

The reentry of OSTP into STI activities would open new possibilities for cooperation with OMB in

[20]U.S. Office of Management and Budget, Bulletin 89-17, "Federal Information Systems and Technology Planning," Aug. 22, 1989.

[21]For the original plan, now being updated, see U.S. Department of Defense, Defense Logistics Agency, Defense Technical Information Center, *DTIC 2000: A Corporate Plan for the Future*, DTIC/TR-84/3, July 1984. Also see, for example, T. Lahr and D. O'Connor, *An Evaluation of DTIC's Prototype CD-ROM* (Alexandria, VA: Defense Technical Information Center, August 1989); C.W. Shockley, D.F. Egan, C.H. Groth, Jr., and D.J. O'Connor, *Meeting the Scientific and Technical Information Challenge*, Report DL605R2, contractor report prepared for DTIC (Bethesda, MD: Logistics Management Institute, October 1988); Aerospace Structures Information Analysis Center, *Application of New Technologies to DTIC Document Processing*, contractor report prepared for DTIC, August 1987; and G.A. Cotter, *The DOD Gateway Information System: Prototype Experience*, DTIC/TR-86/6, April 1986.

[22]This committee was rechartered by OMB in 1989. See memorandum from Richard G. Darman, OMB Director, to Heads of Executive Departments and Independent Establishments, "Coordination of Federal Digital Cartographic Data Program," Feb. 28, 1989; also see memorandum from Lowell E. Starr, Chairman, to Participants, Federal Interagency Coordinating Committee on Digital Cartography Governmentwide Forum, "FCCDC Recommendations for an Improved Federal Spatial Coordination Process," Dec. 5, 1989.

Technical standards can bridge among different formats so that once the information is in the system, it can be processed, edited, revised, stored, and disseminated in electronic, paper, or microfiche formats.

jointly carrying out executive branch STI policymaking and oversight.

Upgrading Agency STI Management

Agency management of STI needs to be strengthened, and OSTP-OMB cooperation could help.[23] Information dissemination should have a higher priority. Most agencies give scant attention to dissemination, even though dissemination was included in the original Information Resources Management (IRM) program concept, and is referred to in the Paperwork Reduction Act (as amended in 1986). IRM officials and activities are mostly occupied with computers, telecommunications, management information systems, and procurement activities. Job definitions, career paths, and training programs for information dissemination professionals and IRM officials could be revised and strengthened to reflect the importance of STI.

STI dissemination should have higher priority within agency R&D programs as well. STI is the primary product of R&D and is central to agency R&D missions. Several possible actions to upgrade STI deserve consideration:

- the direct participation of STI staff in agency R&D planning and decisionmaking;
- the assignment of technical information officers to major science agency operating units;
- the separation of dissemination as a line item within agency R&D budgets;
- the allocation of at least some minimum percentage of R&D grants, contracts, and operating budgets to STI dissemination, data management, and related areas;
- the participation of R&D program officials in selected interagency STI groups and activities;
- the participation of R&D grantees, contractors, and the like in agency innovation centers designed to share new information about STI dissemination, among other topics;
- the involvement of R&D and STI managers in focus group discussions with and surveys of STI users; and
- the joint sponsorship of independent research on STI dissemination and use (perhaps with cooperation from NSF).

Further research on STI use needs to emphasize the barriers as well as opportunities presented by electronic formats. For example, what conditions—equipment, software, training, experience—contribute to successful use of electronic formats? Is the research on use of online formats applicable to offline formats like compact optical disk? How effective are end users in conducting their own searches of STI databases compared with using intermediaries (e.g., librarians, commercial vendors)? Is existing search-and-retrieval software sufficiently user-friendly to make widespread, decentralized use a reality? Are users able to adapt to the availability of STI in multiple and changing formats? In sum, agencies need to guard against "technophoria."[24] While electronic formats are well-suited to STI, disseminating agencies should not adopt electronic formats uncritically without a good understanding of the impact on STI users.

Developing Standards and Directories for STI

Technical standards are essential if the government is to make improvements in cost-effectiveness and productivity and assist the private sector to use Federal STI. Technical standards can bridge among different formats so that once the information is in the system, it can be processed, edited, revised, stored, and disseminated in electronic, paper, or microfiche formats. Standards developed for Federal STI should be compatible with those adopted by the private sector and the international standards-setting

[23]For a general critique of agency information management as it relates to STI, see C.R. McClure, A. Bishop, and P. Doty, "Federal Scientific and Technical Information (STI) Policies and the Management of Information Technology for Dissemination of STI," in *Information Technology: Planning for the Second 50 Years*, Proceedings of the 51st Annual Meeting of the American Society for Information Science, Christine L. Borgman and Edward Y.H. Pai (eds.) (Medford, NJ: Learned Information Press, 1989). Also see U.S. Congress, Office of Technology Assessment, *Informing the Nation: Federal Dissemination in an Electronic Age*, OTA-CIT-396 (Washington, DC: U.S. Government Printing Office, October 1988).

[24]Term coined by C.R. McClure, Syracuse University School of Information Studies.

organizations. Priority areas for standards-setting include:

- STI indexing and cataloging (standard formats are needed, so that NTIS, GPO, and mission agencies are using compatible approaches);
- STI quality control (especially for preventing or minimizing errors in collecting data and creating documents, and for maintaining data and document integrity throughout the information life cycle);
- STI security (technical and administrative standards for preventing unauthorized use or alteration of Federal STI);
- text markup and page/document description languages (e.g., Standard Generalized Markup Language, which has been issued as an international standard and as a Federal Information Processing Standard (FIPS));
- optical disks (there has been significant progress on CD-ROM standards, e.g., for mastering, formatting, and reading, but not yet for search and retrieval software; standards for WORM, Erasable, and CD-I disks are in earlier stages of development); and
- electronic data interchange (EDI), including the open systems interface (OSI) concept (e.g., an OSI procurement standard has been issued as a FIPS and becomes mandatory in late 1990; a proposed EDI standard has been issued for comment).

STI managers, users, and private vendors generally agree on the need for interoperability among various systems and equipment. The Federal Government can accelerate the development and adoption of the standards needed to ensure interoperability. The National Institute of Standards and Technology (NIST), working with GPO, NTIS, and the Federal science agencies, could help in this standards-setting effort. DoD is important in this process, because it and the defense industry together account for two-thirds of the Federal R&D budget and have invested hundreds of millions of dollars in CALS (Computer-Aided Acquisition and Logistical Support). CALS is designed as a standardized system for the electronic exchange of technical data, drawings, and documents.

Large STI databases—such as in the geographic, space, and earth sciences—must have technical standards for data archiving and exchange, if these resources are to be managed and used effectively. Geographic information systems (GIS) will permit greater data exchange among the Federal science agencies. GIS require the integration of multiple data sets—frequently originating from several different agencies. Most Federal agencies with GIS applications are using data sets from several other agencies.[25] GIS must have standards to ensure interoperability among users in these agencies. Most agencies using GIS have not yet developed standard definitions and/or classifications for the major thematic data categories used in GIS applications and do not have an operational program to collect and manage standardized data.[26] The OMB-chartered Federal Interagency Coordinating Committee on Digital Cartography (chaired by the U.S. Geological Survey) has made progress in developing a standard format for Federal geographic information storage and exchange.[27]

NASA is active in standards for space science data. The Science Data Systems Standards Office (at NASA's National Space Science Data Center (NSSDC)) is responsible for standards development. It works with the national and international standards organizations, validates standards, and disseminates information about standards that are important to space science data collection, storage, and dissemination.

[25]U.S. Interagency Coordinating Committee on Digital Cartography, Reports Working Group, "A Summary of GIS Activities in the Federal Government," August 1988, pp. 16-18.

[26]Ibid., pp. 13-15.

[27]See, for example, U.S. Federal Interagency Coordinating Committee on Digital Cartography, Standards Working Group, "Federal Geographic Exchange Format: A Standard Format for the Exchange of Spatial Data Among Federal Agencies," Dec. 15, 1986, U.S. Interagency Coordinating Committee, "Coordination of Digital Cartographic Activities in the Federal Government," Third Annual Report to the OMB Director, 1988. For discussion of the need for a directory to GIS activities and improved Federal/State/local cooperation on GIS, see Lisa Warnecke, "Georgraphic/Land Information Development Coordination Clearinghouse and Network," Syracuse University, School of Information Studies, January 1989, and "Geographic Information Coordination in the States: Past Efforts, Lessons Learned, and Future Opportunities," in *Piecing the Puzzle Together: A Conference on Integrated Data for Decisionmaking*, proceedings, National Governors Association, Center for Policy Research, May 27-29, 1987. For recent updates on GIS standards and related topics, see U.S. Department of the Interior, *Study of Land Information*, prepared in accordance with Public Law 100-409, November 1989 draft; Dec. 5, 1989, memo from Lowell E. Starr, U.S. Geological Survey, on "FICCDC Recommendations for an Improved Federal Spatial Data Coordination Process," and agency responses thereto. For general background on the Interagency Coordinating Committee, see Memorandum from Richard G. Darman, Director, Office of Management and Budget, to Heads of Executive Departments, Establishments, and Independent Agencies, "Coordination of Federal Digital Cartographic Data Programs," Feb. 28, 1989.

The NSSDC has a generic data storage standard, known as the Common Data Format, that is being beta-tested by NASA laboratories and others.[28]

The standards-setting effort in the earth sciences is being led by the Interagency Working Group on Data Management for Global Change, whose members include NASA, NOAA, NSF, USGS, the U.S. Navy, and the Departments of Energy, Agriculture, and State. The working group has emphasized technical standards to facilitate the exchange of data directory information and data sets. Standards are needed to enable users to access earth sciences data on a variety of computers, over a range of electronic networks. This includes the need for standards on data quality. The working group has involved NIST in its standards-setting activities. The National Research Council's Scientific and Technical Information Board (formerly the Numerical Data Advisory Board) also emphasizes the role of NIST in developing governmentwide standards for a variety of large-scale scientific and technical databases.

Directories to Federal STI are also needed to help users find the information they seek. Some are concerned that a directory or index might be used by OMB to thwart rather than encourage agency information dissemination. But OMB has taken steps to quiet this concern. Under the OMB plan, each agency would maintain a current, comprehensive inventory of information dissemination products and services, including: periodicals, nonrecurring publications, machine-readable datafiles (including compact optical disks), software, online databases, and electronic bulletin boards. Each inventory would serve as an index to agency information and would be submitted to a central collection point and compiled into a governmentwide index.[29] NTIS and GPO could collaborate on preparation of a governmentwide directory, and start by collecting and consolidating available agency-specific directories. OMB intends to establish an interagency group to develop an improved structure and content for agency inventories.

Directories to large-scale scientific databases as well as STI documents should be included in these efforts. The proliferation of space science electronic databases—offline and online—is an example of the importance of directories to users seeking specific information. NASA's Master Directory offers online access to a directory of NASA and other space and earth science data sets and related information. For each data set, the directory includes a descriptive title, abstract, references, contact persons, archival information, storage media, and technical details (e.g., parameters measured, scientific discipline, spatial coverage, time period). The directory allows connection to other information systems or database directories.[30] The NASA directory concept may be applicable to other Federal science agencies, and could be made available to the Federal depository libraries and other Federal information dissemination facilities. NASA is also developing expert "data navigation" systems: software to help users rapidly search, access, manipulate, and display data.

The Interagency Working Group on Data Management for Global change is developing and adapting NASA's master directory into an "interoperable directory" that will provide access to information about global change data. Earth sciences data will be maintained by each agency on a decentralized basis, along with detailed catalogs or inventories of its data sets. Summaries of the data sets will be in a central directory that can route inquiries to the detailed catalogs located at individual data centers and can also transfer data among the various data centers and users. Both online and offline electronic services will be available.[31]

The operational version of the directory will include the following Federal earth sciences data centers or systems: NASA (National Space Science Data Center including the NASA Climate, Ocean, and Land Data Systems); NOAA (National Oceanographic Data Center, National Geophysical Data Center, National Climatic Data Center); and USGS (Earth Science Information Center, Earth Resources Observation Systems [EROS] Data Center, National

[28]U.S. National Aeronautics and Space Administration, Goddard Space Flight Center, National Space Science Data Center, *NSSDC Data Listings*, NSSDC-88-01, January 1988.

[29]See Office of Management and Budget, "Second Advance Notice of Further Policy Development on Dissemination of Information," *Federal Register*, vol. 54, No. 114, June 15, 1989, pp. 25554-25559.

[30]U.S. National Aeronautics and Space Administration, Goddard Space Flight Center, *The National Space Science Data Center*, NSSDC-88-26, January 1989, pp. 5-6.

[31]U.S. National Aeronautics and Space Administration, Goddard Space Flighzt Center, National Space Science Data Center, "Report on the Third Catalog Interoperability Workshop, Nov. 16-18, 1989," James R. Thieman, Mary E. James, and Patricia A. Bailey (eds.), March 1989.

Water Data Exchange [NAWDEX], and Earth Science Data Directory, among others).[32] For example, USGS has an Earth Science Data Directory that can be queried from remote computer terminals to identify and locate over 2,000 databases in fields such as geology, hydrology, and cartography. The directory includes: a description of each database; time and geographic coverage of the data; frequency of data updating; type of computer; and person(s) responsible. (USGS does not charge for online access, although users pay their own telecommunication charges.)

The working group and participating Federal agencies are supporting the development of an Arctic environmental data directory to further test the directory concept on a small scale. Arctic climate is thought to be a sensitive indicator of global change. Thus the arctic data directory should have direct utility to the global change research program, and it can also serve as a prototype for a larger earth sciences data directory. CD-ROM is being used for disseminating the Arctic data directory, selected data sets, and reference and bibliographic materials relevant to polar regions.[33]

Launching an STI Education Initiative

Improving U.S. science education is important to renewing U.S. competitiveness. Federal STI can be used to teach students about science and technology and assist them in acquiring basic information search and retrieval skills that are applicable to many careers in the information age.

STI data sets could be used—either online or on disk—for computer models and simulations in science laboratories. Students could use computer-based references and data in their work on topics like energy, environment, health, and space. It is possible to design computer-based enhancements to the science and math curricula that are matched to student skill levels for each year in school.[34]

Federal science agencies could sponsor pilot projects in local elementary and secondary schools to demonstrate the use of Federal STI in the science curriculum.

Schools and colleges have already made a significant investment in microcomputers; but as yet, aside from the major research universities, STI is rarely used in the classroom. Federal agencies, libraries, and private vendors have limitless opportunities to provide accessible and affordable STI to elementary and secondary schools as well as colleges and universities.[35] There is a pressing need to break the routine of science education, bring more excitement into the program, and involve the students directly.[36] Computer-based STI might help capture the interest and enthusiasm of elementary and intermediate students through more "hands-on" science, and strengthen the quality of science education as well. The implications for high school and collegiate science could be profound.

"Hands-on" science means emphasis on observing, critical thinking, and doing rather than rote memorization of facts. Some science education materials already include computer software and could be extended to Federal STI databases online or

[32] See, for example, U.S. Interagency Working Group on Data Management for Global Change, "Interagency Session on Data Management for Global Change," meeting minutes dated Sept. 18, 1987, and Mar. 3, 1989.

[33] See Aug. 8, 1988, memo from Thomas L. Laughlin, Coordinator, Arctic Environmental Data Workshop, National Oceanic and Atmospheric Administration, to Arctic Environment Data Directory Working Group; Douglas R. Posson, "Arctic Environmental Data System: Results from the Boulder, Colorado, Workshop," *Arctic Research of the United States*, Fall 1988, vol. 2; and Feb. 3, 1989, memo from Douglas R. Posson, Chairman, Arctic Environmental Data Directory Working Group, USGS, to Working Group Members.

[34] For a detailed discussion of opportunities for computer-based mathematics education, see National Research Council, Mathematical Sciences Education Board, *Reshaping School Mathematics: A Philosophy and Framework for Curriculum* (Washington, DC: National Academy Press, 1990), and *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (Washington, DC: National Academy Press, 1989); and National Council of Teachers of Mathematics, Commission on Standards for School Mathematics, *Curriculum and Evaluation Standards for School Mathematics* (Washington, DC: National Council of Teachers of Mathematics, March 1989).

[35] Some private vendors already offer various Federal STI databases at educational or school library discount prices that range from 25 to 40 percent off the list price.

[36] Al Saley, President, Society of School Librarians International, telephone conversations with F.B. Wood of OTA, October and November 1989.

on disk; many more curricular materials are well suited to the use of Federal STI as course supplements. The range of possibilities is illustrated in table 2.

The degree of difficulty in the course materials could be scaled to the educational level. But the important point would be to include Federal (and other) STI as a component, where appropriate, in student workbooks, teacher supplements, subject matter overviews, and even "take-home" software packages for use on the family microcomputer or at the local library or science museum.[37]

Several recent studies have focused on the problems and challenges of U.S. science education,[38] but few have considered the role of Federal STI or STI generally. OSTP could provide leadership in this area, perhaps working with FCCSET or other advisory bodies, and launch a science education initiative based on Federal STI, or include Federal STI as part of a broader science education program. An STI education initiative could encompass the following kinds of major activities:

1. *Federal science agency STI pilot projects in local schools.* Federal science agencies could sponsor pilot projects in local elementary and secondary schools to demonstrate the use of Federal STI in the science curriculum. The various Federal agency data centers could make copies of prototype Federal STI CD-ROMs available at no or nominal charge and perhaps provide start-up training on a pilot basis in collaboration with the educational community.[39] This would help teachers and students better understand the potential of Federal STI in user-friendly electronic formats. Local schools could also experiment with online access to Federal data centers, and with electronic networking for both data (and document) transfer and distance learning.[40]

Table 2—Illustrative Use of Federal STI as Science Education Course Supplements

Topic	Application/media
Earthquakes: Land in Motion	Students could analyze the 1989 California earthquake in perspective of long-term trends, other major quakes and their geographic distribution, using data from NOAA's National Geophysical Data Center (CD-ROM).
Earth: The Water Planet	Students could examine current stream flows, lake levels, and precipitation (rain, snow) for regional variations and long-term trends, using USGS water data and NOAA climatic data (online, CD-ROM).
Space: The Last Frontier	Students could explore the solar system through the eyes of space probes such as Mariner and Voyager, using imagery from the NASA National Space Science Data Center (videodisk, CD-ROM).
Toxic Waste: Silent Danger	Students could identify toxic waste dumps in their vicinity, determine the chemicals involved, and analyze the toxicological and environmental effects, using databases from the EPA and NLM (online, CD-ROM).

SOURCE: Office Technology Assessment, 1990.

2. *Federal educational programs with STI applications.* The Department of Education, Department of Defense, and National Science Foundation have major programs in science, engineering, and mathe-

[37]The National Science Teachers Association and National Council of Teachers of Mathematics both have developed extensive curricular materials that could be reviewed for potential Federal STI applications.

[38]See American Association for the Advancement of Science, *Science for All Americans: Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology* (Washington, DC: 1989); U.S. National Research Council, *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (Washington, DC: National Academy Press, 1989); and U.S. Congress, Office of Technology Assessment, *Educating Scientists and Engineers: Grade School to Grad School*, OTA-SET-377 (Washington, DC: U.S. Government Printing Office, June 1988).

[39]The U.S. Geological Survey (in collaboration with NOAA and NASA) is implementing project JEDI—Joint Earth Sciences Educational Initiative—to bring earth sciences information in CD-ROM format to high school students and teachers in northern Virginia. The primary JEDI goal is "to invigorate the teaching of earth science studies in our primary and secondary schools throughout the country. . .through the creation of a stimulating and innovative set of teaching materials." And NASA is implementing project LASER—Learning About Science, Engineering, and Research—to bring NASA science and technology resources, including STI, to K-12 teachers and students. The project uses teacher workshops, public libraries, audio/visual materials, and mobile laboratories (equipped with computer access to NASA's Spacelink STI system) to enrich science and mathematics education and develop "hands-on" activities that reinforce student interest in science and math.

[40]For general discussion, see U.S. Congress, Office of Technology Assessment, *Critical Connections: Communication for the Future*, OTA-CIT-407 (Washington, DC: U.S. Government Printing Office, January 1990); and OTA, *Linking for Learning: A New Course for Education*, OTA-SET-430 (Washington, DC: U.S. Government Printing Office, November 1989).

matics education.[41] Many of these programs permit and sometimes require the use of computer technology as part of teacher training, curriculum development, and instructional support activities.

The Hawkins-Stafford School Improvements Act of 1988[42] authorizes the use of funds for training math/science teachers in computer use, and for purchase of computer hardware and software. Title VI of the Omnibus Trade and Competitiveness Act of 1988[43] authorizes demonstration programs in technology education to:

- inform students about technology applications;
- develop student skills in using technology;
- prepare students for life-long learning in a technological society; and
- improve teacher competency in technology education.

Under OSTP coordination, these programs could be reviewed for opportunities to include Federal STI.

Technology-enhanced use of Federal STI is an appropriate topic for teacher training and student projects. The National Science Teachers Association has endorsed science education initiatives to develop curricula to instruct teachers on the use of technology in the classroom, and provide electronic technologies to science teachers at all grade levels.[44]

3. *Federal science agency collaborative projects with science museums, associations, and high-tech information companies.* Science museums are very successful in the "hands-on," interactive approach to science education. Most science museums use microcomputer-based displays, games, or tutorials, and some provide microcomputer laboratories for intensive computer experience. Computer-based demonstrations of Federal STI applications would be a direct extension of current activities. Federal scientific and bibliographic databases could be operated on a stand-alone basis (e.g., with a dedicated microcomputer using diskette, hard disk, or CD-ROM formats). Science museums with modems could access online Federal STI databases directly from the government and/or private vendors.

Improving the information literacy of U.S. scientists and engineers is one of the most highly leveraged ways to increase the return on the U.S. R&D investment.

Federal STI also could be included in science education programs sponsored by scientific associations and/or private companies. The American Association for the Advancement of Science (AAAS) and a telephone company cosponsor a program to help middle and high school science teachers learn about new communications and information technologies, and how these technologies can be used in science classes. Federal STI would be a natural addition to this type of program.[45] Several private vendors offer substantial educational discounts for off-peak online access to various STI databases, including some Federal STI.

4. *Federal collaboration with library and information science professionals.* Libraries and the professional library and information science schools offer untapped potential for improving the use of Federal STI. Libraries at the major research universities are well-versed in Federal STI and electronic databases generally. But in many public and school libraries, the use of electronic databases is just beginning. In elementary and secondary schools, the problem is compounded because the role of librarians in facilitating electronic access is only dimly understood.

[41]See C.M. Matthews, *Science, Engineering, and Mathematics PreCollege and College Education*, IB 88068 (Washington, DC: Congressional Research Service, Nov. 3, 1989) and *Science and Engineering Education: The Role of the Department of Defense*, Report 89-256 SPR (Washington, DC: Congressional Research Service, Apr. 18, 1989); U.S. Congress, Office of Technology Assessment, *Educating Scientists and Engineers*, op.cit., footnote 39, and *Power On: New Tools for Teaching and Learning*, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988).

[42]U.S. Congress, Public Law 100-297, the "Augustus F. Hawkins and Robert T. Stafford Elementary and Secondary School Improvements Act of 1988."

[43]U.S. Congress, Public Law 100-418, Title VI, Subtitle 2, "Instructional Programs in Technology Education"; see J.B. Stedman, *Computers in Elementary and Secondary Schools: An Analysis of Recent Congressional Action*, Report 88-419 EPW (Washington, DC: Congressional Research Service, June 9, 1988).

[44]National Science Teachers Association, "Science Education Initiatives for the 1990s," position paper, Sept. 7, 1988.

[45]See W. Worthy, "Diverse, Innovative Programs Revive Precollege Science Math Education," *Chemical and Engineering News*, Sept. 11, 1989, pp. 7-12.

Professional groups such as the Society of School Librarians are attempting to bring new information technologies into the school library setting, and recognize the relevance of Federal STI. Under OSTP leadership, Federal agencies could collaborate with the school librarians to help make this vision a reality.

OSTP and the Federal agencies could reach out to the Nation's schools of library and information science and initiate a dialog on how to improve the collegiate curriculum on STI, working closely with the schools of science, engineering, and technology. The objective would be to educate more librarians and information scientists with a specialty in STI, and upgrade courses on information skills in the academic science and engineering programs. Improving the information literacy of U.S. scientists and engineers is one of the most highly leveraged ways to increase the return on the U.S. R&D investment. Business leaders and academic scholars increasingly recognize this need.[46]

Improving International Exchange of STI

U.S. scientists and engineers are generally not conversant in foreign languages and do not read many foreign language documents. Only a small percentage of foreign language material is translated into English, and even here, U.S. demand for such translations has been weak. The problem is two-fold: many U.S. researchers do not sense the need to consider foreign STI, and do not have the skills needed to do so even if they wanted.[47]

Congress enacted the Japanese Technical Literature Act of 1986 to improve U.S. access to Japanese STI. NTIS is responsible for implementing the act, has agreements with about 50 Japanese information sources, and offers online access to some Japanese databases. OSTP could review how well the act is working, and whether the concept should be extended to other foreign countries. Computer-aided translation offers great promise for enhancing U.S. access to foreign STI. OSTP could examine how progress in this area can be accelerated.

OSTP also could review U.S. bilateral and multilateral science and technology (S&T) agreements to ensure that STI is sufficiently covered. STI is an explicit U.S. objective in implementing the U.S.-Japan S&T Agreement (i.e., to improve the flow of Japanese STI to the United States), and an STI Task Force is focusing on computer-assisted translation of Japanese literature for private industry, academic, and government laboratory users in the United States.[48] OSTP is taking a lead in the U.S.-Japan agreement, a role that could be extended to many other S&T agreements, and to other aspects of U.S. access to foreign STI. These include education and exchange programs for U.S. and foreign researchers, and cooperative agreements between U.S. and foreign STI agencies.

The consensus seems to favor open, reciprocal exchange of STI, with restrictions on access kept to the minimum. OSTP should take the lead in balancing the open flow, national security, and competitiveness concerns that arise in dealing with international STI issues.

The principle of open, reciprocal STI access has been accepted for years in the civilian scientific research community (as contrasted with military or commercial research). Global change research exemplifies the importance of international STI collaboration and the complexities involved. The U.S. Interagency Working Group on Data Management for Global Change recognized from the outset that earth sciences data must be collected and disseminated globally to foster research on global change. The Federal earth science agencies have dozens of international agreements for information exchange, and these could be the basis for an international data network, if data systems are made compatible. The working group is coordinating with several national and international scientific organizations on earth sciences data management, including:

- National Research Council Space Science Board, Committee on Data Management and Computation;

[46]See statement of C.R. McClure, Professor of Information Studies, Syracuse University, before a hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology, Oct. 12, 1989.

[47]See C.H. Hill, "Enhancing U.S. Access to Foreign STI: What Should be the Federal Role," in McClure and Hernon (eds.), *Federal Scientific and Technical Information*, op. cit., footnote 19, pp. 172-192.

[48]See memorandum from D. Allan Bromley, Director, OSTP, to U.S. Members of the Joint High Level Committee on the U.S.-Japan Science and Technology Agreement, Nov. 20, 1989.

A common frustration to those working on international data systems is the lack of a receptive audience at the senior levels of the government. This is beginning to change with regard to STI for global change.

- National Research Council, Numerical Data Advisory Board (recently renamed the STI Board);
- National Research Council, Committee on Geophysical Data;
- International Geosphere/Biosphere Program, Data Management Working Group;
- International Council of Scientific Unions, Panel on World Data Centers;
- Committee on Earth Observation Satellites, Working Group on Data;
- Committee on Data for Science and Technology (CODATA); and
- World Climate Data Program.

A common frustration to those working on international data systems is the lack of a receptive audience at the senior levels of the government. This is beginning to change with regard to STI for global change.

The challenge of managing global change data is mammoth. NASA's Earth Observing System alone will generate an additional terabyte (10^{12} bytes) of data every day. This is equivalent to 10,000 Washington, DC telephone books (white pages) or 520,000 text books (at 200 pages each) per day.[49] Electronic technologies offer the only hope for managing this data (see appendix). The Interagency Working Group has concluded, after several years of effort, that the size and geographic scale of global data require new approaches to data management and international cooperation if the potential of these technologies is to be realized.[50]

Table 3—Illustrative Weaknesses in Current Global Change Data Management

Weakness	Explanation
Data quality	Many data sets lack credibility due to inconsistent or poor documentation and quality control.
Data management procedures	There are no established criteria or policies for evaluating, archiving, and updating global data sets.
Data management technologies	New technologies are not applied in a consistent or coordinated manner to global data sets.
Data management infrastructure	The data systems to handle increased observational data are not yet in place.
Global change data sets	Very few data sets have been compiled and processed for the specific purpose of monitoring and detecting climate change.
Satellite data calibration	Despite 25 years of satellite observations, only one satellite data set is sufficiently well-calibrated to document global change.
Data archives	Retrospective data sets are poorly cataloged, inconsistently documented, inaccessible, and subject to an undisciplined publication process.
Data standards	Data formats and exchange mechanisms are inadequately standardized. Standards that exist are not uniformly adhered to.

SOURCE: Committee on Earth Sciences, 1989.

Data management is critical to the success of global change initiatives. The U.S. Global Change Research Program now includes data management in the overall plan, and presents a detailed data management strategy.[51] However, the problems that need attention are daunting, as highlighted in table 3.

While some might question the severity of reported data management problems, the need for international cooperation is compelling. As the Committee on Earth Sciences concluded:

> Data management requires global and international cooperation. . .No one nation, agency, or institution will be able to gather the appropriate data without cooperation from other nations, other agencies, and other institutions. Individual agencies will need the cooperation of others to collect, manage, and preserve data sets systematically for global change and make them accessible across the traditional discipline and agency boundaries.[52]

[49] See R. Kahn, "Coping With All the Earth Science Data," *EOS*, vol. 69, No. 21, May 24, 1988, pp. 609, 612.

[50] U.S. Interagency Working Group on Data Management for Global Change, "Interagency Session, Minutes," June 2, 1989.

[51] U.S. Federal Coordinating Council for Science, Engineering, and Technology, Committee on Earth Sciences, *Our Changing Planet: The FY 1990 Global Change Research Plan* (Washington, DC: OSTP, July 1989), pp. 91-99.

[52] Ibid., p. 94.

Appendix A
Technological Opportunities for Managing and Disseminating Federal Scientific and Technical Information

Introduction to the Electronic STI Revolution

Dissemination of Federal STI is being transformed by the ongoing revolution in electronic information and telecommunication technologies. The scientific and technical community is one of the heaviest and most advanced users of computers. The vast majority of U.S. scientists and engineers have a microcomputer at work and/or at home, and some have access to mainframe and high-performance computer resources either onsite or through telecommunication networks. The microcomputer or workstation provides the scientist or engineer with a versatile tool. Continuous, steady improvement in the price/performance of microcomputers has resulted in the power of a 1970s-vintage mainframe computer now being on the desktop of the typical scientist. The microcomputer can be used to search, recover, and store STI on magnetic or optical media, manipulate and analyze STI using a variety of software, and access STI remotely via online bulletin boards, computer conferences, and database networks.[1]

Online information networks serve at least three important needs of the scientific and technical community. First, they are used for the transfer of very large streams of STI, for example, from a central repository of data collected by Earth-observing satellites to regional data repositories and to individual research institutions or user groups. Second, online networks are used to search STI bibliographic databases and to remotely access large-scale high-performance computers. Third, online networks are used for informal exchange of STI among researchers, for example, an electronic bulletin board on research in progress or upcoming key events, a computer conference for exchanging working notes and ideas among scientists conducting related research, and electronic mail for submission of manuscripts and review comments to scientific and technical journals and to funding agencies.[2] Online STI dissemination benefits from both a proliferation of online gateways that provide channels for electronic information exchange (offered by telecommunication common carriers, value-added carriers, and not-for-profit and governmental systems), and a growing variety of STI services (especially bibliographic and reference services offered by commercial and not-for-profit organizations as well as some government agencies). Advances in online STI gateways and information services are made possible in part by progress in underlying digital telecommunication technologies (e.g., packet switching, fiber optics, and satellite networking). The net result is that online is feasible over a broader range of STI dissemination applications than ever before.

Dissemination of Federal STI is being transformed by the ongoing revolution in electronic information and telecommunication technologies.

The package of online and optical disk technologies offers a powerful combination. Online can be effectively used when time or geographic factors are most important (e.g., bibliographic updates on just-published research, access to remote computing resources or to international STI databases) and offline optical disks can be used for large data sets and/or extensive data manipulation and analysis requirements that are not time-sensitive and would be much more expensive online (even at off-peak rates).

The future of STI dissemination will be dominated by electronic formats. Some major types of STI—e.g., satellite remote sensing data or the results of large-scale computer models—are created, stored, transmitted, and used in electronic form. These data are rarely, if ever, converted to paper or microfiche, except when summarized and analyzed in technical reports and scientific papers. By comparison, STI bibliographic and reference materials are currently offered and used in paper, microfiche, and electronic formats (principally online and Compact Disk-Read Only Memory (CD-ROM)). Full-length reports and documents are still largely distributed on paper or microfiche. However, electronic publishing is rapidly taking over the document preparation and production process. Most STI documents are created electronically with word processing systems or software, even though the output is still on paper or microfiche.

[1]See U.S. Congress, Office of Technology Assessment, *Informing the Nation: Federal Information Dissemination in an Electronic Age*, OTA-CIT-396 (Washington, DC: U.S. Government Printing Office, October 1988).

[2]See National Academy of Sciences, Committee on Science, Engineering, and Public Policy, *Information Technology and the Conduct of Research: The User's View* (Washington, DC: National Academy Press, 1989); U.S. Congress, Office of Technology Assessment, *High Performance Computing and Networking for Science*, OTA-BP-CIT-59 (Washington, DC: U.S. Government Printing Office, September 1989).

The package of online and optical disk technologies offers a powerful combination.

Electronic publishing makes it possible to carry the advantages of electronic word processing through all stages of document preparation and information dissemination. Electronic publishing creates an electronic document database that can be accessed online, stored on magnetic or optical media, or printed out in whole or in part on paper or microfiche. The major barrier to realization of the "intelligent database" is standardization of data structures and file formats for graphics and datasets as well as text.

The price/performance of all electronic publishing components continues to improve. This is resulting in a continued narrowing of the gap between relatively inexpensive desktop systems and expensive, high-end electronic publishing and phototypesetting systems. Desktop systems can be linked to very fast, very high-quality phototypesetters and printers.

Desktop publishing and dissemination functions benefit from steady progress in development of expert systems. The expert systems applicable to STI dissemination are no different in principle from the systems that have been successfully applied to other scientific, industrial, and educational areas. Expert systems with sophisticated search strategies can be used to retrieve and deliver bibliographic or full-text STI from offline (e.g., CD-ROM) or online information systems. Expert systems can improve the dissemination process by accounting for such factors as: the profile of the information product (number of pages, layout, type style, use of graphics, etc.), anticipated user needs (e.g., size of demand by format), and the modes of dissemination (press run, provisions for demand printing in paper or microform, online database access, optical disk distribution, etc.). Expert systems can also assist SDI (selective dissemination of information) by matching user interest profiles with available databases, and, potentially, in translation of STI from foreign languages to English (and vice versa).

Over the next 3 to 5 years, use of printed Federal STI is likely to decline modestly, while the use of electronic formats will likely increase dramatically. Some transitional effects are already evident. For example, the National Technical Information Service (NTIS) experienced a roughly 50 percent reduction in sales of paper and microfiche copies of reports between 1980 and 1989. The reduction is attributed in part to the effectiveness of online searching of the NTIS bibliographic database (offered via private vendors).[3] The fastest growing NTIS product line now is computer products. The Office of Scientific and Technical Information at the Department of Energy has noted a similar declining demand for paper and microfiche copies over the past decade as reliance on computerized bibliographic databases increases.[4]

Surveys conducted by the General Accounting Office have documented the plans of Federal agencies to increase their use of electronic formats for STI, and the growing demand of STI users for electronic formats. The survey results indicated a 50 percent or greater anticipated increase over a 3-year period in the number of civilian agencies using electronic mail, electronic bulletin boards, floppy disks, and compact optical disks for STI dissemination. The results showed a doubling over the next 3 years in the number of scientific and technical associations desiring Federal STI in electronic formats. For Federal depository libraries, the results indicated, for example, about an eight-fold increase over the next 3 years in demand for Federal STI on compact optical disks. In contrast, the results showed a projected decline in demand for paper and microfiche formats of about 15 to 20 percent.[5]

A key to realizing the potential for technology-enhanced dissemination is the "information life cycle," where STI dissemination is part of the larger process of collection/creation, storage, processing, and archiving. The stages in the STI process need to be integrated with interconnected technologies to be cost-effective. Thus the cost and delays associated with rekeyboarding, incompatible equipment, and the like can be reduced.

Another key is to substantially upgrade technology training for the scientific and technical community. Recent surveys have concluded that many scientists and engineers are still not comfortable with online and ondisk systems.[6] At present, user education and training receive

[3]U.S. Congress, Office of Technology Assessment, *Informing the Nation*, op. cit., footnote 1, pp. 112-114; U.S. National Technical Information Service, "Annual Report to the Congress on NTIS: Operations, Audit, and Modernization," January 1989.

[4]Bonnie C. Carroll, Office of Scientific and Technical Information, U.S. Department of Energy, "DOE Reports Distribution Program: Current System and Why Change Is Needed," Apr. 30, 1986.

[5]U.S. General Accounting Office, *Federal Information: Agency Needs and Practices*, Fact Sheet for the Chairman, Joint Committee on Printing, U.S. Congress, GAO/GGD-88-115FS, September 1988; and U.S. General Accounting Office, *Federal Information: Users' Current and Future Technology Needs*, Fact Sheet for the Chairman, Joint Committee on Printing, U.S. Congress, GAO/GGD-89-20FS, November 1988.

[6]See statement of Charles R. McClure, Professor of Information Studies, Syracuse University, before a hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology, Oct. 12, 1989.

Over the next 3 to 5 years, use of printed Federal STI is likely to decline modestly, while the use of electronic formats will likely increase dramatically.

minimal attention. In order to fully realize the potential of electronic technologies for STI, user training needs to be viewed and funded as an integral part of STI system development. Once exposed to electronic STI and trained in its use (whether formally or through self-or collegial-learning), the users frequently become technology enthusiasts.[7]

The convergence of trends in technology and in user preference for electronic data, combined with the emergence of systems integration and standards for the STI life cycle, offer an almost limitless array of possibilities for STI dissemination. Several of these are highlighted below in the context of Federal science agency applications.

Cartographic/Geographic Information

Many aspects of science and technology depend on geographic information—frequently in the form of maps that show the location of transportation networks, natural resources, climate regimes, environmental sources, and the like. In the past, these maps were prepared by hand and printed on paper. Over the last 15 years or so, mapmaking has been computerized, and satellite imagery has been incorporated along with data from field surveys and aerial photogrammetry. But the final product was and still is largely printed on paper. Over the last 5 years advances in computer technologies have culminated in "nothing less than a cartographic revolution."

This revolution is being driven by digital cartography combined with powerful hardware and software that can access and manipulate geographic data from multiple sources. By collecting information in digital (as opposed to analog form), or by converting analog data (e.g., aerial photographs) to digital form, the data can be readily processed by computers to produce a vast array of computer products. Digitized maps can be displayed on computer screens and recorded on magnetic and optical media, for example, as well as used to produce traditional printed maps.[8]

The U.S. Geological Survey (USGS) expects that many of these digitized maps will be produced in CD-ROM format at a fraction of the cost of the equivalent magnetic tapes or printed paper documents. USGS pilot tests of CD-ROM indicate that it is likely to be an order of magnitude less expensive than computer tapes, and will require only a microcomputer and CD-ROM reader rather than a more expensive mini- or main-frame computer needed for tapes.

Optical disks will revolutionize STI storage and dissemination. Optical disk technology uses a laser beam to record data on plastic disks by engraving pits in the surface. Encoded disks can be read by a low-power laser beam to retrieve the data. Other members of the optical disk family include: WORM (Write Once Ready Many-times); Erasable disks; Videodisk (for storing film or still photos); and CD-I (Compact Disk-Interactive) that combines text, data, video, audio, and software capabilities on one disk.

The CD-ROM is rapidly gaining acceptance, and the basic technical standards are already in place. The marginal cost of producing CD-ROMs is very low—currently about $2 per disk at volumes of several hundred or more. The full cost can be as much as $50 to $500 per disk for several hundred, if the costs of data preparation, premastering, and mastering are included. But even this compares favorably with other storage media. Each CD-ROM can store up to about 600 megabytes (millions of bytes) of data. This is equivalent to about 300,000 text pages (assuming 250 words or about 2,000 bytes per page). One CD-ROM can store the equivalent of about 1,650 floppy diskettes, 30 of the 20-megabyte hard disks, 15 of the 1,600 bits-per-inch 9-track magnetic computer tapes, or 4 of the 6,250 bits-per-inch computer tapes. Thus a $2 CD-ROM can store as much as several hundreds of dollars' worth of magnetic media. Microcomputer-based CD-ROM authoring software now costs less than $1,000. Agencies with heavy CD-ROM activity might be able to justify purchase of a premastering system ($50,000 to $100,000), but will need to contract out for mastering and duplication.

USGS issuing CD-ROMs with cartographic and geographic information on a variety of topics, such as:

- Gloria Sidescan Sonar Data—contains data for the Gulf of Mexico and parts of the eastern Pacific Ocean, produced by USGS, NOAA, and NASA, and available from USGS;

[7]See John R.B. Clement, "Increasing Research Productivity Through Information Technology: A User-Centered Viewpoint," manuscript submitted to "Research Reviews in Information and Documentation," October 1989; also see National Academy of Sciences, *Information Technology and the Conduct of Research: The User's View*, op. cit., footnote 2.

[8]U.S. Federal Interagency Coordinating Committee on Digital Cartography, "Coordinating of Digital Cartographic Activities in the Federal Government," Sixth Annual Report to the OMB Director, 1988.

The U.S. Geological Survey expects that many of these digitized maps will be produced in CD-ROM format at a fraction of the cost of the equivalent magnetic tapes or printed paper documents.

- Aerial Photography Records—contains aerial photographs from the USGS National Cartographic Information Center (recently renamed the Earth Science Information Center);
- Joint Earth Sciences—contains sidelooking airborne radar data, prototype produced by and available from USGS, Bureau of Land Management, and Soil Conservation Service;
- Hydrodata—contains daily measurement data for USGS water gage stations, produced and sold by Earth Info., Inc. (for profit, formerly U.S. West Optical Publishing); and
- USGS Reference Materials—contains GEO Index (a database of geologic maps) and Earth Science Data Directory, produced and sold by OCLC, Inc. (not-for-profit, Online Computer Library Center).

Space Science Data

The collection of scientific data by satellites and rockets—already very extensive—will increase further over the next few years, as a new generation of Earth- and space-observing satellites, manned space missions, and interplanetary and deep space probes is launched. The storage and dissemination of these data pose a major challenge to the Federal science agencies—and especially to the National Aeronautics and Space Administration (NASA). Several new electronic technologies have the potential to avoid total systems overload from the expected avalanche of space data.

NASA's primary institution for space data management and dissemination is the National Space Science Data Center (NSSDC) located at the Goddard Space Flight Center in Greenbelt, Maryland. NSSDC is the largest space data-archive in the world, with about 85,000 magnetic tapes of digital data currently on file (along with another 35,000 backup magnetic tapes). The NSSDC archives only processed data, not the raw telemetry data received directly from space. The center also archives a large volume of photographs and film taken by satellites and space missions. Some data are maintained on microform or hard copy. At present, the center archives about 4,000 different data sets, mostly from NASA missions but with a few from Department of Defense or foreign missions. The center retains no classified data, and the primary users are researchers from the disciplines of astronomy, astrophysics, lunar and planetary science, solar terrestrial physics, space plasma physics, and earth sciences.[9]

The opportunities are substantial for use of optical disks to store and disseminate space science data. NASA is beginning to experiment with both 12-inch WORM and 4.75-inch CD-ROM. One WORM product is currently available for dissemination (the data from 20 magnetic tapes were transferred to one WORM disk). And four prototype CD-ROM products are available: 1) a CD-ROM space science sampler that includes a cross-section of planetary, land, oceans, astronomy, and solar-terrestrial data ($50 for the CD-ROM, software on floppy disk, and documentation); 2) a 3-disk CD-ROM set of Voyager/Uranus images ($100 for the disks, software, and documentation); 3) a 5-disk CD-ROM set of Voyager/Jupiter and Saturn images ($175 for the disks, software, and documentation); and 4) a CD-ROM produced by the NOAA National Geophysical Data Center that includes solar wind and magnetic field data from NASA and various geomagnetic and solar data from NOAA (disk and basic software free while they last; $100 for advanced software and updates).

An understanding of the potential of optical disks can be gained from the following hypothetical examples. The Apollo 17 lunar mission generated about 240 magnetic computer tapes of digital data, 32,000 feet of 16 mm color photographs, and 39,000 feet of 16mm black-and-white photographs.[10] These digital data could be stored on about 4 double-sided 12-inch WORM disks. (One 12-inch WORM disk can store 1.2 gigabytes per side—equivalent to 30 of the 1,600 bits-per-inch magnetic tapes. A two-sided WORM disk can store 2.4 gigabytes or 60 tapes of data.) With 4:1 data compression, it would be possible to store the Apollo 17 data on one WORM disk. The 16mm photographic data, which in this example are equivalent to roughly 850,000 individual photographs, could be stored on about 17 analog videodisks (at the standard 54,000 images per videodisk).

For some of the earlier missions, data for entire series of mission activities could be consolidated. For example, the Mariner interplanetary mission series generated the following volumes of digital data in number of magnetic tapes: Mariner 2 (5 tapes); Mariner 4 (10 tapes); Mariner 9 (42 tapes); and Mariner 10 (184 tapes).[11] The total of

[9] See U.S. National Aeronautics and Space Administration, Goddard Space Flight Center, *The National Space Science Data Center*, NSSDC-88-26, January 1989.

[10] U.S. National Aeronautics and Space Administration, Goddard Space Flight Center, *NSSDC Data Listings*, NSSDC-88-01, January 1988.

[11] Ibid.

286 magnetic tapes could be stored on about 5 double-sided 12-inch WORM disks (without data compression). The NSSDC archive provides clear evidence of the proliferation of space data over time, as the number and sophistication of space missions increased.

New optical and magnetic storage technologies make it possible for NSSDC to carry out a gradual transition from magnetic tapes and photographic film to higher density storage media such as optical disks or digital tape cartridges (not tape reels, see later discussion on earth sciences data) for digital data and videodisks for analog data. This transition will be quickest for newly acquired data, and for historical data that needs to be re-recorded on new media (i.e., due to deterioration of magnetic tapes, many of which are more than 10 years old and written on obsolete technology).

At the same time, demand for online data dissemination is also increasing. NSSDC is making more data sets available online either over networks or on a dial-up basis. Network options currently include: SPAN (the Space Physics Analysis Network) that links DECnet-based computers in the United States, Canada, Europe, Japan, Australia, New Zealand, and South America; NSN (NASA Science Network) that links with NSFnet and the ARPANET-based Internet; BITNET that links various universities and research organizations; and Telenet, a public packet-switching data network.[12]

Second, technical evaluations and guidelines will need to be developed on when and how to use these media for storing and disseminating data. How fast should high-density storage media be phased in, and what kinds of data sets are best suited for WORM, CD-ROM, videodisk, digital tape cartridge, and other storage technologies? These guidelines will need to take into account the ability of users to accommodate high-density storage media, in terms of training, equipment, and cost. What are the highly leveraged data sets that are both best suited for the new media and matched to user capabilities to handle high-density storage? And the guidelines will need to consider the appropriate balance between offline high-density storage media and online dissemination.

At present, NSSDC includes only a small number of data sets in the online program, and generally limits online time to one-half hour or less. This restriction is based in part on the limited transmission speeds (e.g., still 9.6 kilobits or occasionally 56 kilobits per second, for many universities) such that longer transmissions cost more than offline dissemination. However, online will become more cost-effective as transmission speeds increase. NASA itself already has a 1-megabit/second transmission network for use by NASA laboratories and centers. And the proposed multi-agency national research and education network (NREN) anticipates transmission speeds of 1-gigabit/second or more in the future.[13] Some current online space science data sets include:

- International Ultraviolet Explorer Satellite, contains ultraviolet spectral data, sponsored by NASA, European Space Agency, and British Science and Engineering Council;
- Total Ozone Mapping Spectrometer, contains 120 days of ozone data from the Nimbus 7 satellite, sponsored by NASA;
- Space Telescope Archive and Catalog, contains catalogs of astronomical data and various observing logs from spaceborne astronomy missions, sponsored by European Space Telescope and Southern Observatory; and
- Crustal Dynamics Data Information System, contains catalog of data from Satellite Laser Ranging, Lunar Laser Ranging, Very Long Baseline Interferometry, and Global Positioning System experiments, sponsored by NASA, National Geodetic Service, and various universities.

Earth Sciences Data

Over the last several years, the Federal science agencies, and the scientific community generally, have made a significant effort to improve the collection, management, and dissemination of earth sciences data. This effort is driven by the widespread concern over problems of global change—ranging from climate change and deforestation to air and water pollution to soil erosion and demineralization to drought—and the recognition that better understanding of these global problems requires much better information. The concept of the Earth system has emerged as an important organizing principle, since global change involves all major earth subsystems—the atmosphere, oceans, snow and ice, lakes and rivers, land formations, and the biosphere (e.g., trees, plants, and animals) and can be affected by forces from deep within

[12] U.S. NASA, *Data Center*, op. cit., footnote 9, pp.15-16; also see U.S. Congress, Office of Technology Assessment, *High Performance Computing*, op. cit., footnote 2.

[13] See U.S. Office of Science and Technology Policy, Executive Office of the President, *The Federal High Performance Computing Program*, Sept. 8, 1989; and U.S. Congress, Office of Technology Assessment, *High Performance Computing*, op. cit., footnote 2.

the Earth (e.g., volcanoes and earthquakes) and from far in space (e.g., changes in solar radiation).[14]

The earth system concept is being used to organize the vast array of data relevant to the disciplines that comprise the earth sciences—climatology, oceanography, glaciology, hydrology, biology, biogeochemistry, geology, etc. In the U.S. Government, the long-term objective is to develop a "virtual" interagency information system for global change data. "Virtual" means that the information system will be a family of decentralized data centers, most of which already exist in some form, linked together by common directories, standards, and policies on access, user charges, quality control, and the like. The goal is to have the system fully implemented by the time that NASA's planned Earth-observing system is operational in the late 1990s (and thus generating a large additional volume of earth sciences data).[15]

In the U.S. Government, the long-term objective is to develop a "virtual" interagency information system for global change data. "Virtual" means that the information system will be a family of decentralized data centers.

As is the case for space science data, the most effective technology for managing this massive volume of data is high-density storage. Some of the smaller data centers could be converted entirely to a combination of WORM and CD-ROM. For example, the National Oceanographic Data Center, operated by NOAA, maintains about 12 gigabytes of processed data in the following categories: chemical data (marine chemistry), pollutants/toxic substances); biological data (e.g., fish/shellfish, marine birds, plankton); and physical data (e.g., wind/waves, current, subsurface temperature). NODC also maintains about 12 gigabytes of raw, unprocessed data. The entire NODC database of 24 gigabytes would fit on about two to twelve double-sided 12-inch WORM optical disks, depending on the data compression ratio. As new data accumulate, the WORM disks could be updated. Those portions of the database in high demand could be extracted, mastered, and duplicated at very low cost on CD-ROM, and updated CD-ROMs could be issued periodically.

Several Federal earth science data centers are experimenting with CD-ROM. One is the National Snow and Ice Data Center, operated by the University of Colorado for NOAA's National Geophysical Data Center (NGDC). The Snow and Ice Data Center has issued a prototype CD-ROM with data on Northern Hemisphere "brightness temperature grids," which are collected by a NASA satellite and used to estimate the polar sea ice parameters. The CD-ROM disk comes with a software diskette and a user's guide, and is available free while supplies last. This is the first in what is planned as a series of CD-ROMs, and reflects a shift in data dissemination philosophy to offline low-cost optical disks for many research purposes.[16] In general, the NGDC believes that CD-ROM will greatly improve the accessibility and usability of STI by the research community, as well as by governmental and private-sector organizations that depend on geophysical data.

The larger data centers are also considering high-density magnetic as well as optical storage. For example, the EROS (Earth Resources Observation Systems) Data Center, operated by USGS, archives about 6 million frames of aerial photographs and over 1 million Landsat and other remotely sensed satellite images. The Landsat imagery alone is roughly equivalent to 75 terabytes (or 75,000 gigabytes) of digital data. Because of this large volume, the EROS Data Center is considering the digital tape cassette as the next generation high-density storage medium. Each cassette can store up to 50 gigabytes of data, much more than either CD-ROM (about 0.6 gigabyte per disk, or 4 gigabytes with 6:1 data compression) or WORM (1.2 gigabytes per disk up to about 12 gigabytes for a two-sided disk with 6:1 data compression). Digital cassettes have a faster data transfer rate than optical disks. On the other hand, the digital tape cassette is a magnetic medium that, like magnetic computer tape reels, deteriorates over time and needs a tape refresh every 7 to 15 years. This compares with a projected lifetime of 20 to 30 years or more for optical disks (the longevity of optical media is still uncertain). The cassettes and equipment cost considerably more than comparable optical disk systems. Optical disks also have the advantage of random (as opposed to sequential) access and

[14]See J.A. Eddy, "The Earth As A System," *Earth Quest*, 1987, vol. 1, No. 1, pp. 1-2, available from the Office of Interdisciplinary Earth Studies, University Corporation for Atmospheric Research, Boulder, CO; U.S. National Aeronautics and Space Administration, Earth Systems Science Committee, *Earth Systems Science: A Closer View* (Washington, DC: NASA, January 1988); F.B. Wood, Jr., "The Need for Systems Research on Global Climate Change," *Systems Research*, 1988, vol. 5, No. 3, pp. 225-240; U.S. National Oceanic and Atmospheric Administration, Panel on Global Climate Change, *The Vision: A Rededication of NOAA*, January 1989; and R. Corell, "A Paradigm Emerging," *Earth Quest*, 1990, vol. 4, No. 1, pp. 1-4.

[15]See, for example, U.S. Interagency Working Group for Data Management of Global Change, "Interagency Session on Data Management for Global Change," minutes of meetings dated Sept. 18, 1987, Nov. 24, 1987, and Mar. 18, 1988.

[16]U.S. National Geophysical Data Center, National Snow and Ice Data Center, Data Announcement, "Scanning Multichannel Microwave Radiometer (SMMR) Brightness Temperatures for the Northern Hemisphere," June 1, 1989; also see R. Weaver, C. Morris, and R.G. Barry, "Passive Microwave Data for Snow and Ice Research: Planned Products From the DMSP SSM/I System," *EOS*, Sept. 29, 1987, pp. 776-777.

microcomputer compatibility (with inexpensive, user-friendly software). Optical tape is another storage technology that warrants consideration. One 12-inch reel of optical tape can store up to a terabyte of data. Preparation and duplication cost, expected level of use, storage capacity, data transfer rate, data access time, longevity, and equipment and training requirements are among the factors that need to be considered in evaluating alternative storage media.

Drought Monitoring Information

Electronic technologies open up new alternatives for dissemination of time-sensitive Federal STI, such as drought information, that is widely used (contrasted with the very large space and earth sciences data sets that are less time-sensitive and have fewer users). Drought information is collected and disseminated by the U.S. Department of Agriculture and NOAA. The NOAA/USDA Joint Agricultural Weather Facility and NOAA Climate Analysis Center produce several drought-related reports and bulletins, such as the *Weekly Weather and Crop Bulletin.*

Should the government decide to prepare and distribute a weekly or monthly electronic drought bulletin, it might include: temperature and precipitation trends and forecasts; streamflow, lake (and reservoir) level, and snow pack trends and forecasts; soil and plant (including forest) moisture conditions; soil quality conditions (e.g., mineral content, depth of topsoil); crop conditions; and overall drought indices (e.g., the Palmer drought severity index). The information could be presented on a county, State, regional, and national (and international) level, and would be ideally suited for use with analytical and presentation software (e.g., using spreadsheet or graphics techniques).

Agency pilot tests and experience in other areas suggest several prototypes for electronic dissemination that could be applied to drought (or other) time-sensitive Federal STI. The "best" approach depends on the type of information, number and types of users, importance to the agency mission and statutory guidance, agency precedents, budgetary constraints, related private sector alternatives, and the historical and political context.

A weekly or monthly drought bulletin could be made available on an agency electronic bulletin board for dial-up access by users over commercial telecommunication lines. This approach is used, for example, by the National Science Foundation's "science indicators" bulletin board and the Department of Commerce's "economic bulletin board." Or the drought bulletin board could be disseminated online via the computer center of a single agency contractor, an approach used by the Securities and Exchange Commission (for corporate financial information) and USDA (for various agricultural reports and bulletins). Alternatively, an agency computer center could be employed. For instance, the Environmental Protection Agency is making its "toxic release inventory" available online via the National Library of Medicine computer center. And the U.S. Geological Survey provides data on earthquake epicenters online from the National Earthquake Information Center in Golden, Colorado. Finally, the drought bulletin board could be offered as a service of private sector commercial or not-for-profit value-added information gateways and vendors.[17]

Electronic technologies open up new alternatives for dissemination of time-sensitive Federal STI, such as drought information.

Forest Monitoring Information

Concern about forest ecology is growing. The need for monitoring forest health reflects: 1) mounting evidence of forest decline due to changing environmental, climatic, and soil conditions, among other factors; and 2) growing appreciation of the key role of forests in stabilizing ecosystems and climate on local to global scales.[18]

Because of the rural, remote location of most forests, monitoring in these areas has, until recently, been logistically difficult and expensive. Advances in information and telecommunication technologies now make it possible to provide for efficient and cost-effective monitoring of remote locations. For example, before the microcomputer revolution, temperature and precipitation typically were measured at remote locations with a hydrothermograph that recorded the data on chart paper. In order to retrieve that data, someone had to periodically visit the monitoring site, tear off the chart paper, and carry the chart paper back to a central location where the data

[17]See statements of Edward J. Hanley, Director, Office of Information Resources Management, U.S. Environmental Protection Agency, John Penhollow, Director, Office of EDGAR Management, U.S. Securities and Exchange Commission, and John J. Franke, Assistant Secretary of Administration, U.S. Department of Agriculture, before a hearing of the Subcommittee on Government Information, Justice, and Agriculture, House Committee on Government Operations, Apr. 18, 1989. Also see U.S. Department of Commerce, Under Secretary for Economic Affairs, "Request for Comments on the Preliminary Implementation Plan of Subtitle E, Part I of the Omnibus Trade and Competitiveness Act of 1988, the National Trade Data Bank," Apr. 21, 1989.

[18]See U.S. Department of Agriculture, Forest Service, "Forest Productivity and Health in a Changing Atmospheric Environment," Conceptual Plan for the Forest/Atmosphere Interaction Priority Research Program, 1988.

Advances in information and telecommunication technologies now make it possible to provide for efficient and cost-effective monitoring of remote locations.

was extracted and logged in. The data had to be typed in if computer processing (e.g., calculation of means and standard deviations) was desired. This largely mechanical and manual process was (and is, where still used) labor-intensive, expensive, and prone to data quality problems. Frequently, the data were collected only sporadically (e.g., by forest rangers on trail maintenance duty), and was logged in and compiled on an erratic basis. As a result, temperature and precipitation records for many rural monitoring stations were incomplete or nonexistent.

Microcomputers and satellites are transforming the nature of remote monitoring and providing a valuable information resource for both research and management purposes. Digital data recorders (at under $1,000 each) are replacing the hydrographs. These simple devices record environmental and climatic data on a removable digital chip that stores 45 to 60 days of data. The chips still have to be picked up by someone and carried to an office, but once there, the data can be entered directly from the chip into a microcomputer for data storage and manipulation. Daily, monthly, seasonal, and annual means, among other statistics, can be readily calculated. Remote automated monitoring stations (costing $10,000 to $15,000 each, with a satellite dish) can be used to electronically collect and transmit the data via satellite to a central location. For example, the U.S. Interagency Fire Center in Boise, Idaho, collects climate data via a NOAA satellite from about 500 remote weather stations located on forested lands (260 stations operated by the U.S. Forest Service, 200 by the Bureau of Land Management, and 40 by the National Park Service and Fish and Wildlife Service).

Both the Forest Service and National Science Foundation are funding rural monitoring networks to meet forest ecology and climate research needs. The Forest Service has a "long-term forest ecosystem monitoring program" to measure selected physical and biological parameters, establish baseline conditions, and detect changes over time. The program builds on existing stations located in experimental forests, experimental rangelands, and research natural areas. Most stations require equipment upgrades and more consistent data collection and analysis. For example, only 16 of 83 experimental forests have long-term data sets (i.e., more than 15 to 20 years), and some of these sets are incomplete or currently inactive.

The monitoring information will help researchers and resource managers determine changes in forest composition and species distribution resulting from air pollution, climate, and soil changes. This in turn should be important input to ecological models used to predict forest growth, commercial tree yield, forest and rangeland habitat and carrying capacity, fire frequency and severity, recreational opportunities, and the like.

To the extent possible, experimental forest monitoring stations are being colocated with the "long-term ecological research" field sites funded by NSF. These sites are designed to study the ecology of a diversity of natural landscapes—including forest, prairie, desert, and aquatic environments. The intent is to better understand the patterns of organic decomposition, primary photosynthetic production, food webs, biogeochemical cycling, nutrient movement through soils and groundwater, atmospheric deposition, and climatic change.[19] Standardized meteorological data collection is being implemented at the various ecological sites, so that baseline conditions are adequate for detection (and documentation) of both cyclic and long-term climatic change.[20] The ecological stations together with the more well-established experimental forest stations provide reasonably balanced geographic coverage of the United States, with one or more stations in the following States: Alaska, Washington, Oregon, California, Idaho, Arizona, New Mexico, Kansas, Minnesota, Wisconsin, Michigan, Illinois, Mississippi, Georgia, South Carolina, North Carolina, Virginia, West Virginia, New York, Massachusetts, and New Hampshire.

The Forest Service and NSF include the dissemination of monitoring information to users as an important objective. Advances in information technology can make this a cost-effective reality. For example, the monthly data for each monitoring station could be sent via inexpensive floppy disk or electronic mail or bulletin board to a designated central location. This could be a Forest Service office, or a research university, or the National Climatic Data Center (operated by NOAA) or National Technical Information Service. The central office or center would quality control and consolidate the data on one disk or magnetic tape. Depending on the data volume and demand, the consolidated data could be issued periodically in floppy disk, magnetic tape, and/or CD-ROM

[19]See James C. Halfpenny and Kathryn P. Ingraham (eds.), *Long-Term Ecological Research in the United States: A Network of Research Sites*, Forest Sciences Laboratory, Corvallis, OR, 1984; James T. Callahan, "Long-Term Ecological Research," *BioScience*, vol. 34, No. 6, June 1984, pp. 363-367.

[20]David Greenland (ed.), "The Climate of the Long-Term Ecological Research Sites," Occasional Paper No. 44, Institute of Arctic and Alpine Research, University of Colorado, 1987.

formats. An electronic bulletin board could also be cost-effective for disseminating monthly data sets.

In sum, electronic information technologies both: 1) help make the forest and ecological monitoring system a reality, and 2) help make it possible for the monitoring results to be shared among the research community and other public- and private-sector users at little marginal cost to either the government or the users.

Energy Research Documents

Electronic information technologies also open up new possibilities for the dissemination of Federal scientific and technical documents that traditionally have been maintained in paper and microfiche formats. An estimated 200,000 such documents are generated annually, with more than half of the total originating from the Department of Energy, Department of Defense, or NASA.

Advancing technologies create new alternatives for electronic dissemination of both Federal STI bibliographic databases and the STI documents themselves. The activities of the DOE Office of Scientific and Technical Information are illustrative. DOE/OSTI currently distributes about 14,000 documents per year in paper or microfiche format to NTIS and in microfiche to the Depository Library Program (DLP). Abstracts of the documents are included in both the DOE bibliographic database called "Energy Data Base" and the NTIS bibliographic database. While the depository libraries receive paper copies of *Energy Research Abstracts*, which contain abstracts of DOE-funded research, the libraries have online access to the DOE and NTIS bibliographic databases only through private vendors at commercial rates.

To meet its own internal needs, DOE has implemented an Integrated Technical Information System (ITIS), which provides DOE employees and contractors with online access to the most recent 14 months of the Energy Data Base. DOE has proposed a pilot test to offer depository libraries similar online access. Besides timely access to the Energy Data Base (compared with the paper format *Energy Research Abstracts*), the pilot would provide an electronic "gateway" to archival energy research summaries (maintained on a database by a commercial vendor), and "electronic cataloging" of DOE documents in a format compatible with that used by depository libraries (and the Library of Congress).[21]

Another aspect of the DOE pilot test is a study of alternative formats for document distribution. Over the next few years, DOE, like other Federal science agencies, has the opportunity to convert from paper and microfiche to optical disk as the primary document format. One possibility is to require DOE research offices, laboratories, and contractors to submit all documents in an electronic form (e.g., magnetic tape, online, diskette) that can easily be converted to high-density optical disks (e.g., WORM or CD-ROM). Since the demand for STI documents is generally small, any desired paper copies could be printed on demand. (The more popular documents could be printed in larger volumes with traditional printing processes.)

Advancing technologies create new alternatives for electronic dissemination of both Federal STI bibliographic databases and the STI documents themselves.

The study may show, as a hypothetical example, that DOE could distribute copies of the documents via a bimonthly CD-ROM, rather than on microfiche. A standard double-sided CD-ROM can store about 300,000 pages of material (double-spaced, typewritten) or about 1,500 documents at 200 pages per document. Thus the 14,000 documents could fit on about 10 CD-ROMs. The CD-ROM cost probably would be significantly lower than microfiche (and much lower than paper). At present, DOE pays about $350,000 per year for microfiche production of depository library materials, compared to an estimated $210,000 for mastering CD-ROMs and duplicating 1,400 copies of each (one per depository library). If DOE was able to piggyback depository CD-ROM duplication onto mastering and production for internal and possibly NTIS needs, the cost could be even lower (and savings greater). Compared to microfiche, CD-ROM should be easier to use, permit full-text searching, and provide higher quality document resolution (on the screen or when printed out on demand).

One disadvantage of using a bimonthly CD-ROM is the up to 2-month delay in getting some energy research documents to the depository libraries (and other users). This delay could be alleviated by maintaining the most recent 2 (or perhaps 4) months of documents online in full-text format, for retrieval and printing on-demand. Many private vendors are adopting a similar approach, which combines the strengths of online with CD-ROM formats. Another possible disadvantage is that all participating depository libraries (and other users) would need to have adequate CD-ROM facilities (one or several

[21]U.S. Department of Energy, Office of Scientific and Technical Information, "DOE/Depository Library Gateway: Access to DOE R&D Results in Electronic Form, A Pilot Project Proposal," August 1986; U.S. Congress, Joint Committee on Printing, "Dissemination of Information in Electronic Format to Federal Depository Libraries: Proposed Project Descriptions," June 1988.

microcomputer, CD-ROM drive, and local printer set-ups, depending on the level of use). As CD-ROM readers continue to drop in price and become standard equipment on microcomputers, the availability of CD-ROM equipment will improve, at least in the larger research libraries. Special provisions may be needed—whether through the DLP or otherwise—to ensure that smaller, rural, or economically disadvantaged libraries have CD-ROM equipment.

An inherent advantage of electronic formats such as CD-ROM is that powerful bibliographic, retrieval, and even expert search system software can be included directly on the optical disk or loaded into the microcomputer via diskette. CD-ROM or online versions of the "Grateful Med" user-friendly software developed by the National Library of Medicine (NLM) will be commonplace, whether developed by the government and/or private vendors. NLM developed "Grateful Med" to facilitate user access to MEDLINE and other databases on the NLM MEDLARS (MEDical Literature And Retrieval System). Tens of thousands of copies at $29.95 each have been sold through NTIS. The package includes 2 floppy disks, a user's guide, and an application for a MEDLARS access code. The capabilities of user-friendly software such as "Grateful Med" or numerous commercial software packages can be easily replicated on CD-ROM.

In considering the appropriate role for Federal agencies in online dissemination of STI bibliographic databases, three aspects warrant particular attention. First, most of the Federal scientific and technical agencies have a statutory charter and/or mission objective to promote the wide distribution of information on the results of Federal research and development. Even agencies that operate under restrictions (e.g., NASA) have a strong dissemination mandate. Bibliographic databases are key tools in facilitating access to information on R&D results, and online databases (or for some purposes CD-ROM) offer significant advantages in terms of timeliness and ease of search and retrieval. Thus agencies need to be sensitive to equity of access to Federal STI, and ensure that, whatever means of online dissemination may be employed, certain user groups are not disadvantaged. Students, teachers, retired scientists, small business persons, and the like may need special consideration.

Second, development and dissemination of online bibliographic databases (and now CD-ROM versions of same) are strengths of the private commercial and not-for-profit information industry. A wide range of excellent STI bibliographic databases has been developed by private vendors that offer a portfolio of STI databases (including some from Federal agencies) over information gateways and value-added networks. Again, equity of access is a concern since full commercial online rates can range from $75 to $150 per hour or higher for privately developed databases, and commercial rates range from about $40 to $80 per hour for government databases (two to four times the comparable government rate). On the other hand, commercial vendors increasingly are proposing or offering a variety of discounts for off-peak or bulk volume use, that are more affordable for students, teachers, and the general public. Private sector not-for-profit vendors are providing some databases at rates between full commercial and governmental levels.

Third, a Federal STI bibliographic database may or may not be less expensive if offered online by the government. There is no clear-cut answer. Each situation requires individual analysis. For example, adding an online database to an already existing online computer capability (e.g., at NLM) or providing expanded access to an existing online system (e.g., depository library access to the DOE system) may have minimal marginal costs, if the existing computer center could handle the additional file and/or users without costly upgrades or expansion. In these situations, the incremental or marginal cost of additional computer use may be minimal, and competitive with comparable private-sector costs. On the other hand, if this required an upgrade of agency computer capability, the cost could be higher. For setting up a small electronic bulletin board, the cost of a new system is likely to be modest, but for a large, heavily used bibliographic database, the cost could be substantial. In making decisions on online bibliographic (or other online) systems, agencies will need to consider the quality of service, agency mission, equity of access, and related private-sector activities, in addition to cost-effectiveness.

With respect to CD-ROM (and other optical storage media), the situation is clearer. It seems likely that for some types of Federal information, and especially various STI documents, high-density optical storage will largely supplant paper and microfiche. It is not a question of whether this will happen, but when. Federal agencies will, in all probability, make this transition themselves in order to meet their statutory mission and records management responsibilities. The agencies may employ any of several means to make this transition, including private contractors, NTIS, and/or GPO. But the end result is likely to be the availability of many or most Federal STI documents on optical disk, at affordable prices, with powerful built-in search and retrieval capabilities, that will be cost-effective compared to paper or microfiche. This upgrade may also offer many new opportunities for the private sector to develop more value-added applications and products.

Appendix B
List of Acronyms

Acronyms

- CALS —Computer-Aided Acquisition and Logistical Support
- CD-I —Compact Disk-Interactive
- CD-ROM —Compact Disk-Read Only Memory
- CENDI —Commerce, Energy, NTIS, Defense Information
- COSATI —Committee on Scientific and Technical Information
- DLP —Depository Library Program
- DoD —Department of Defense
- DOE —Department of Energy
- DTIC —Defense Technical Information Center
- EDB —Energy Data Base
- EDI —Electronic Data Interchange
- EDGAR —Electronic Data Gathering and Retrieval
- EPA —Environmental Protection Agency
- EOS —Earth Observing System
- EROS —Earth Resources Observation Systems
- ETDE —Energy Technology Data Exchange
- FCCSET —Federal Coordinating Committee on Science, Engineering, and Technology
- FIPS —Federal Information Processing Standard
- FOIA —Freedom of Information Act
- GIS —Geographic Information Systems
- GPO —Government Printing Office
- IIA —Information Industry Association
- IRM —Information Resources Management
- JCP —Joint Committee on Printing
- LOC —Library of Congress
- NAL —National Agricultural Library
- NARA —National Archives and Records Administration
- NASA —National Aeronautics and Space Administration
- NGDC —National Geophysical Data Center
- NIST —National Institute of Standards and Technology
- NLM —National Library of Medicine
- NOAA —National Oceanic and Atmospheric Administration
- NODC —National Oceanographic Data Center
- NSA —National Security Agency
- NSF —National Science Foundation
- NSSDC —National Space Science Data Center
- NTIS —National Technical Information Service
- OIRA —Office of Information and Regulatory Affairs
- OMB —Office of Management and Budget
- OSI —Open Systems Interface
- OTA —Office of Technology Assessment
- OSTP —Office of Science and Technology Policy
- PSAC —President's Science Advisory Committee
- PRA —Paperwork Reduction Act
- PTO —Patent and Trademark Office
- R&D —Research and Development
- SDI —Selective Dissemination of Information
- SupDocs —Superintendent of Documents
- STI —Scientific and Technical Information
- S&T —Science and Technology
- TRI —Toxic Release Inventory
- USGS —United States Geological Survey
- WORM —Write Once-Read Manytimes

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